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ADOLESCENCE AND THE SEX PROBLEM.

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There can be no thorough understanding of the sex problem until we study it in relation to adolescence. The first question that confronts one in this study is the problem of the psychology of the adolescent. We may well review briefly a few of the most important facts recognized by psychologists as peculiar to the age in question.

In the first place, the psychic functions are just as surely the product of a progressive evolution from the simplest to the most complex, from the lowest to the highest, as are the structures of the body. The lowest forms of animal life show certain reflex and automatic adjustments to the conditions of their environment. These reflex and automatic adjustments represent the simplest possible psychic phenomena. Taking a long step upward in the animal kingdom, we come to the vermes, which, according to Romanes's extensive researches on animal intelligence and the evolution of mind, show clearly marked the emotions of both fear and surprise. Higher animals in order of rank, as for example, fish, insects, birds, carnivorous mammals, and apes, show the following emotions in the order in which they are named; curiosity, pugnacity, anger, jealousy, affection, play, sympathy, hatred, grief, cruelty, remorse, sense of ludicrous, deceitfulness. Each rank of animal possesses the psychic qualities of all lower animals and shows one, two, or three psychic qualities not possessed by the lower orders. In the higher animals, as in the carnivorous mammals, the apes, and the man, these psychic qualities or powers make themselves manifest in the same order in which they first appeared in the animal kingdom. In other words, the individual repeats or recapitulates the history of the race.

The human child at birth is capable of a series of reflex and automatic adjustments to conditions. When it is about three

weeks of age, it begins to show surprise and fear; when about seven weeks of age it shows curiosity, affection, and pugnacity. When three months of age it is capable of jealousy and anger; at five months, play and sympathy; at seven months, grief, hatred, and cruelty; at fifteen months, shame, remorse, deceitfulness; during childhood, resentment and pride; during adolescence, revenge and benevolence.

Accepting the general principles of psychic development as they are now generally accepted by physiologists and biologists we must recognize the youth at the age of adolescence as representing a stage of human development when the race was emerging from savagery into a condition of organized human society; a crude tribal government where tribal chiefs maintained their rule through pure physical force.

I. THE SEX PHENOMENA OF ADOLESCENCE.

These phenomena are psychic and physical in character. Psychic phenomena in both the male and female have been well characterized by the German expression "Sturm und Drang," whose English equivalent is storm and stress, so we must recognize that there is a general breaking up of old relations and instincts in the mind of the youth and their gradual displacement by new thoughts, desires, and instincts. In the light of what has been said above, regarding the recapitulation in the individual, of the history of the race, we may expect to find in these adolescent boys and girls a love of nature, a restiveness under restraint, a tendency to vacillation between extremes of emotion. One day, ambitious; the next day, discouraged; one day, brilliant and happy; the next day, despondent and depressed; one day, too good to live; the next day, too bad to die. The rapid change from one of these mental attitudes to the other makes it very difficult for parents, teachers, or other leaders and associates either to understand or to sympathize with their mental state. The mental quality most needed by parents, teachers, and other guardians of youth is *patience* and this must be possessed in infinite quantities.

In the case of boys at least, the problem may be immensely simplified if they can be, at least for months at a time, brought very close to nature. If there is any possibility of arranging it, every boy should have the benefit of several weeks of camping in the woods and by the water. Improvised camps, caves constructed in the bluff side, lodges built in trees, appeal to the boy in an in-

definable way and seem to put him in harmony with nature. A considerable amount of time may well be spent in fishing and hunting, constructing rafts and simple boats. Such opportunities develop the heroic side of the boy's mind and develop the massive, sturdy powers of his body. It goes without saying that every boys' camp should have at least one, perhaps several, older young men of irreproachable character, monumental patience, phenomenal tact, and herculean strength to serve as leaders of the boys, and to inspire them in all the activities of the camp. Such a leader or group of leaders will use the opportunity afforded by the evening camp-fire, when all "the braves of the tribe" gather close in around the glowing embers and as far as possible, from the disquieting shades of the forest, to tell stories of the heroes of the olden times, and to inspire in the boys, by the word pictures of heroes, a high ideal of manhood.

These psychic phenomena, set forth in some detail as to the boy, but similar in many respects as to the girl, are so indissolubly associated with the sex life that any discussion of the sex phenomena of this period, without mentioning these psychic phenomena, would be incomplete. One of the most noticeable psychic changes of the period is the change of attitude toward the opposite sex. The pre-adolescent youth not only gives little heed to the opposite sex, but as a matter of fact, rather despises them. However, as the months go by the youth who has entered upon his or her adolescent development, will begin to evince a change of attitude toward the opposite sex. There is a marked tendency on the part of girls and boys of twelve to fourteen to play love games that involve the choosing of partners, the chasing of the chosen one, the chase ending in the capture and perhaps even the kissing of the object of the chase. The psychology of these games is interesting. Note that the partner chosen in these games is supposed to be surprised at the choice and runs away and apparently makes every effort to avoid capture. When the object of the chase is a coy maiden of thirteen, this show of running away to avoid capture covers up any embarrassment, and if she is finally caught and even kissed by the fortunate youth, it is all taken as a part of the game and the maid rather glories in the agility and strength of the youth who is able to catch her. Of course, it goes without saying that the girl really down in her heart enjoys the whole procedure though she may feign to be annoyed or even scandalized that the boy should take advantage of her capture by planting a resounding smack on her glowing cheek.

It is not at all difficult to perceive in these love games of early youth a mock social encounter that sustains to real society of the adult, a relation similar to that which the sham battle sustains to the life and death encounter of the armed forces of nations.

Another stage in youthful society is dancing. In the physical and psychic conditions of the dance we have the love games of childhood, modified in such a way as to bring them into harmony with the gradually unfolding modesty and sedateness of young womanhood on the one hand, and the gradually developing chivalry of young manhood on the other hand.

In the dance the same frequent and shifting choice of partners is noted as occurs in the love games; the physical activity involved in the chase here takes the form of a hardly less vigorous chase of the rhythmic measures of the music. The element of contention, however, is furnished in the repartee of conversation, rather than in physical contests. In the place of the stolen kiss, the dance affords a close physical contact almost, if not quite, an embrace which sustains to the developing sex love a relation similar to that which the kiss bore at the earlier period.

In passing, the writer wishes to take the opportunity to assure the reader that nothing in the above paragraph is to be interpreted as indicating that he believes the modern dance as it is usually conducted, frequently with no chaperonage or safeguards, to be a wise or admissible exercise for young people. The folk dances of the peasant people of Europe and similar dances enjoyed by our great-grandparents in the pioneer days of America, are widely different in their social significance and influence from the modern round dance.

The physical phenomena of adolescence hardly needs more than passing notice, as they are quite clearly understood not only by physicians, but also by educators and social workers everywhere. A few salient facts need emphasis. The average boy enters this period sometime during his fifteenth year, some boys become adolescent as early as twelve and others as late as seventeen. When the period begins late, the steps of development are hastened and the whole period of puberty covers perhaps less than two years. On the other hand, when the development begins early, as in the twelfth year, the period of puberty is likely to be protracted to cover at least three years. The period of puberty in girls begins, as a rule, sometime during the thirteenth year and is completed in about two years. In a similar way, some girls

may be adolescent in their eleventh year, while others show no signs of it before the sixteenth or seventeenth. This wide variation seems to be due in part to climate and in part to nutrition. Other factors may play a subsidiary role. The climatic influence is, of course, most pronounced when we compare the people of Southern Europe with those of Northern Europe, where the average differs by about two years—girls of the Latin races developing at least two years earlier than the girls of the Teutonic races.

In the case of a boy, the most noticeable change of puberty is his great increase in stature. In a period of two or three years he increases in stature from six to twelve inches in height, meantime he acquires a proportional breadth of shoulder and depth of chest. While these increased measurements represent for the most part skeletal growth, other changes rapidly follow such as great increase of muscle and of chest and abdominal girths which represent an increase of muscle and gland development. In this period of puberty the youth receives from nature his physical heritage of bone, brawn, and brain— the three B's of young manhood.

During the same years, when the youth is receiving his physical heritage, there is an equally marked development of the sexual apparatus. At the end of the time the young man of seventeen has the sexual equipment of the mature man. His sexual organs are as large as they will ever be.

While the development of the girl into young womanhood is parallel to that of the youth into manhood, still there is this noticeable difference. The youth develops the hirsute and husky hardness of manhood while the girl develops the rosy and radiant gracefulness of womanhood.

2. THE INTERNAL SECRETION FROM THE SEX GLANDS.

There is one phase of adolescent development that deserves more than passing notice, because of the far-reaching importance of the facts and the profound influence of the principles. Reference is here made to the internal secretion from the sexual glands. Our whole knowledge of internal secretions dates back about two decades to the work of Brown-Sequare, Charcot, Zoth, Sajous, and others. As a result of these two decades of research on internal secretions, we have come into possession of a mass of facts of incalculable value to mankind. Our rapidly accumulating knowledge of the internal secretions, from the thyroids, the para-

thyroids, the adrenal bodies, and the pituitary body, enables the physician and the surgeon to cope successfully with many conditions which a decade ago were absolutely baffling.

But these glandular bodies mentioned above are structures which twenty years ago were usually thought to be adequately discussed in a brief chapter entitled "Ductless Glands of Unknown Functions." These glands possess only an internal secretion, and it was not until these researches on internal secretions were made that there was any assignable function for the glands above named.

Furthermore, we have also come into possession of a large body of most important knowledge in regard to other glandular structures, but as these other glands in question each produce an external secretion of great importance, we little dreamed how important a role they might also play as elaborators of an internal secretion. The pancreatic gland, for example, produces so important an external secretion in the pancreatic juice that it did not occur to us to look farther for work for this gland. But the researches of Von Mering and of Opie have demonstrated that this gland produces an internal secretion poured back into the blood which not only influences but actually controls the use of starches and sugars in the body. A pathologic disturbance in the pancreatic gland is uniformly followed by a disturbance in the metabolism of the carbohydrates, notwithstanding the fact that this class of foods may be digested in the alimentary canal, and absorbed into the blood.

Without stopping here to discuss other glands, let us at once enter upon a consideration of the reproductive glands.[1] The most striking evidence of an internal secretion from the reproductive glands is to be found in a study of their influence upon the development of young animals. Frequent references in the oldest writings to "the seed of the man" in context which makes it evident that they referred to the semen of the man, shows that for long ages past men have understood the relation of the secretion of the testicle to fertilization and to the begetting of offspring. The fact that the reproductive glands make a rapid development during the period of puberty was naturally looked upon as a necessary and easily accountable part of physical development. That these glands produce our internal secre-

[1]The more important literature on this particular matter is given at the end of this paper.

tion early in this proces of development never occurred to our forefathers.

The best evidence we have that such a substance is formed in the reproductive glands, and that it profoundly influences the development of the individual is found in the results which follow the removal of the reproductive glands from young animals that have not yet entered upon their adolescence. The recent studies in this particular problem have been carried on in the department of animal husbandry in state agricultural colleges. These observations while technically more accurate and extensive are no more informing and convincing in their results than observations which are comparatively familiar to every youth reared on the farm, provided that youth is a close observer and a logical reasoner. Reference is here made to the effect of castration on the development of young males of the domestic animals and the effect of spaying on the development of young females.

The writer well remembers the case of two young horses on his father's far western ranch. They were pedigreed young stallions two years of age, offspring of full sisters and a common sire, thus unusually closely related. At two years of age they were as alike as two peas in a pod, glossy, dappled brown, high-headed, full of play and full of fight, speedy and graceful in movements. Only the experienced eye could detect any difference between these two colts. Influenced by some trivial difference in their temperaments, my father finally determined to save Morgan as a stallion and to castrate Jack. The third year of the horse's life is his adolescent period. It is the year during which he develops from callow colthood to husky horsehood. At the end of that year Morgan had developed into the finest specimen of horsehood that I have ever seen. He was still full of fire and fight, carrying his noble head high on his proudly arched neck. Massive shoulders and massive hips bespoke power, and every muscle of his body fairly trembled with pent-up virility. When anything aroused him, his eyes blazed forth the unbanked fires of virile horsehood. Morgan was absolutely fearless and absolutely untiring. He was the kind of a horse that generals like to ride into battle. They are afraid of nothing and will carry the general to the belching mouth of a cannon if he wishes to go there.

Jack, the castrated one, was different from the hour he lost his testicles. Never again did he hold his head so high. Never

again did he show fight or fearlessness. He was different. At the end of a year he was just a common gelding; a block away you could not have distinguished him from a mare. Morgan, on the other hand, could have been distinguished from a mare a mile away. These two animals showed almost sufficient physical differences to place them in different species of animals, and the whole difference was due to the fact that Morgan every day of his life received into his blood an internal secretion prepared in the testicles, absorbed into blood and lymph streams in the epididymis and carried to muscles, brain and spinal cord, there to produce its magic influence. Jack, on the other hand, having lost his testicles at the beginning of his adolescence lacked this magical stimulus and grew up lacking the majestic qualities.

The case for the female is analogous throughout. Spaying of a heifer, for example, when she is one year old, leads her to develop not into the typical cow possessing the beautiful maternal instincts and attributes, so familiar the world over, but she grows up into a common ox, well adapted physically to work in the yoke beside the castrated male of her kind, the two making a well-mated yoke of oxen, or as is more usual, in these later years, she is fatted for the market and takes on fat and develops into the general contour typical of a neutral ox of her kind.

What is true of a domestic animal, just discussed, is true in every essential fact and principal for the human subject. Centuries ago in Oriental countries it was common practice to castrate, in early youth, boys born into bondage or sold into bondage. These boys grew up not into men but into eunuchs which were as different from hard-muscled, fiery-eyed, virile men as the gelding is different from the stallion. The sloping shoulders, the flabby muscles, the beardless face, the high-pitched, squeaky voice, the festoons of fat on breast and hips, set forth an effeminacy as pitiable in the eyes of a virile man as it was loathsome to the discerning eyes of a woman. The human male when castrated before puberty grows into a being quite as different from a virile man as a gelding is different from a stallion.

In an analogous way, disease or destruction of the ovaries of a girl before puberty would lead her to develop, not those colorings and graceful outlines, and psychic qualities, that give to radiant young womanhood her transcendent charms, but robbed of all this she develops into a colorless neuter, angular of form,

striding in gait, strident of voice, perhaps even bewhiskered of chin.

3. RELATION OF FACTS OF SEX DEVELOPMENT TO EDUCATION IN SEXUAL HYGIENE.

When these facts set forth above are brought clearly and forcibly to the attention of a youth, either boy or girl, and when at the same time this young person is assured that any excitation of the sex glands through artificial stimulation, as in self-abuse, will interfere with nature's plan for their development into hard-muscled, fiery-eyed, virile young manhood on the one hand, or into graceful, lustrous-eyed, radiant young womanhood on the other hand, then the parent or the teacher may rest confident in the assurance that he has furnished the youth with the strongest possible incentive to right living. This is constructive teaching. Pedagogically it is incomparably better teaching to hold up before the youth a great end to be attained and arouse in him not only a desire but a firm determination to attain that end, than it is to suspend over his head a sword of Damocles, the frailness of whose suspending thread is a continuous menace to his safety. In other words, it is better to hold before his eyes the ideal of a condition much to be desired than the lurid phantom of a thing to be feared. It is better to place before him the picture of a hero in armor—a knight-errant to the lady of his choice—than to shake before his face the blood-stained garment of sin and degradation. The constructive course incites to the best that is in him. The other course hardly deters him from the worst that is in him.

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AN OUTDOOR LABORATORY.

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Every little while some individual with a prejudice in favor of classical studies takes it upon himself to point out to the hard-pressed science teacher that botany is not giving the results expected of it when it was added to the high school course and that there has been a falling off in the number of pupils electing this study. As regards the latter part of this statement the experience of the writer has failed to show any diminution of interest where efficient teachers are employed, but admitting, for the sake of argument, that such a condition of affairs exists, it seems pertinent to inquire whether this is due to the faults of the teacher of science or to the conditions under which he is obliged to teach.

In the average school the biology teacher in endeavoring to present his subject properly is confronted with well-nigh insuperable difficulties and these difficulties, it may be added, do not exist in any other department of the high school. To begin with, the objects of his study are alive and many of the phenomena which he wishes his pupils to investigate are inseparably connected with this condition. The specimens for the work cannot be comfortably stored away on the laboratory shelves along with the maps and models of the physiography teacher, the machines of the physics teacher and the elements and combinations of the chemist ready to hand at any time. On the contrary they must be collected often from a wide range of countryside and used immediately. In many cases the delay of a few hours will render them of little value. No other teacher, after a fair day's work in the class room or laboratory is obliged to spend his spare time in getting together the materials for the studies of the following day, yet the biology teacher must do this or be content with a make-shift course. To be sure he contrives to eke out the work by various pickled and dried specimens in preference to teaching botany "out of a book," but such specimens can never take the place of fresh materials especially when one is dealing with children.

Even the best specimens lose something of the interest and value that attaches to them when living if brought into the schoolroom. One must see the flower in its natural setting, the butterfly, bird, and bee pursuing their everyday life in the open, to thoroughly appreciate any study about them. No naturalist was ever made by studies in the class room nor is any real lover

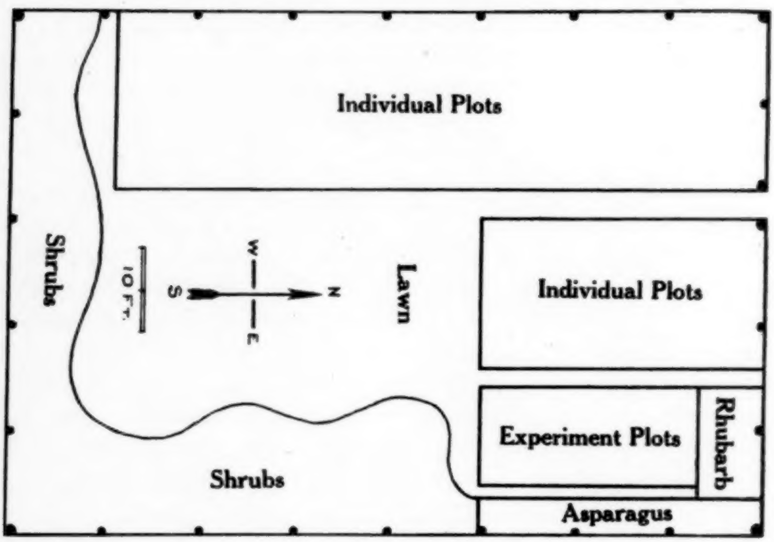
of nature content to take his natural history indoors and at second hand. Good teachers, therefore, aim to introduce as much as possible of this outdoor life into their studies by means of field trips and field studies, but the limitations of the school routine allow but a minimum of these. Boards of education and teachers generally need not expect the best results from either botany or zoölogy until each school is provided with a laboratory more fitted to the needs of these studies than those that exist at present. This, it need hardly be said, should be an outdoor laboratory.

There are a great number of uses to which an outdoor laboratory can be put. First of all, it will nearly double the teacher's efficiency by providing a place for growing nearly all the materials needed in the botanical course, thus relieving him of the necessity of extended collecting trips and the sacrifice of much valuable time. Still more important, it will give the pupil a chance to see his specimens growing and to deal with them as parts of a complete organism instead of as isolated specimens. Such a laboratory will serve as the place where much of the actual work in botany and zoölogy may be performed, and furnish numerous illustrations of economic and ecological relationships that cannot be shown indoors. Properly planted it should also yield all the materials needed for the study of systematic botany with the added advantage that the pupils will be able to study and recognize the plants themselves and not merely the flowering shoots that are usually brought indoors. Here, too, they may see the flowers studied succeeded by the fruits and in due time observe the dissemination of the seeds. And finally, such a laboratory will afford space for studies in the growth and behavior of plants cultivated by the pupils themselves, the decorative planting of lawns and borders, the budding and grafting of woody plants, the propagation of many species, the making and handling of sprays and a multitude of other investigations that are of the very highest practical value but which cannot be carried on indoors.

Such a laboratory should properly be a part of the school grounds but if sufficient space is lacking there, any open ground within ten minutes' walk of the school may be used. Wherever located it should be strongly fenced against the depredations of the small boy. A repellant wire fence may be soon covered with vines, hidden by a hedge or blotted out of the view by plantations of shrubbery. The best situation for such a laboratory is one open to the south and east, but any piece of ground that receives the sunshine for part of the day will serve the purpose.

The cost of such a laboratory, even in the vicinity of most city schools is seldom prohibitive. A single city lot will do if no larger space can be had and can usually be purchased for less than it would cost to fit up a new laboratory indoors.

An ideal laboratory of this kind should consist of lawn, shrubberies and garden. In that part of the ground devoted to gardening, there should be sufficient space for an individual plot for each pupil and in addition smaller plots in which experiments of various kinds may be carried on and unusual food, fiber, and drug plants cultivated. It is probably needless to observe that the sunniest spot in the grounds should be given up to the garden.



The lawn should be large enough to serve as a meeting place for the classes and as a point from which the plant collections can be studied. Extending about the lawn may be borders of shrubs and herbaceous perennials selected for their use as illustrative material in the courses likely to be pursued. A long list of such plants can be made by any teacher but we may here note shepherdia and deutzia for leaves with scales, the locust, prickly ash, and cat brier for forms of stipules, the raspberry, blackberry, and rose for armed stems, lilac, buckeye, pawpaw, viburnum, and others for buds and a host of spring flowering shrubs selected for the use of classes in systematic botany. The herbaceous perennials, placed in front of the shrubbery, may consist of anything that flowers early in the year—violets, bloodroot, irises,

bleeding heart, day lilies, primroses, trilliums, phloxes, pinks, poppies, foxgloves, snapdragons, mallows, and all the bulbous plants. To these, or to the plants in the experiment plots should be added all sorts of variations that the pupils may discover—four-leaved clovers, albinos, cut-leaved forms, plants showing peloria, fasciation or doubling, unusual coloring in flowers and fruits and the like.

Such a laboratory established on a single city lot 60x132 feet in size has been used with excellent results by the writer. A plan of this garden drawn to scale accompanies this article. When larger grounds and more money are available there is no end to the additions that may be made. Hot-beds and cold frames will be most useful, a lath house for shade plants, such as ferns, is desirable, a tool house and workroom, a small greenhouse and various enclosures for zoölogical specimens are among the possibilities. In the far-distant future when botany is taught as well as it deserves to be, no doubt there will be a building properly equipped for indoor study containing workrooms, aquaria, insect cages and the like, tanks for water plants, and a small greenhouse for studies in winter while outside will be well-planted grounds, ponds for aquatics, rockeries, experiment plots, and all the essential features of a small botanical garden. Does anybody suppose that where such laboratory facilities exist botany is a detested subject? If so, he has much to learn about the interest that attaches to real botany and the delight with which both the students and their parents take up the study.

FAUNA OF THE PARK CITY PHOSPHATE BEDS.

The fauna of the phosphate beds of the Park City formation in the Far West is described by George H. Girty in Bulletin 436 of the United States Geological Survey, which may be obtained free on application to the Director of the Survey at Washington.

The report contains careful descriptions and illustrations of the many varieties of fossils unearthed from a series of phosphate-bearing shales, about 100 feet thick, in the States of Utah, Wyoming, and Idaho. The bed is one of the most important of its kind in the country and the fossils, with other data, afford a means of recognizing it as it recurs at different points.

The fauna of the phosphate shales, which is in many respects unique, is here described for the first time. It clearly belongs to that division of geologic time called Carboniferous, but the author has not satisfied himself completely as to the portion of Carboniferous time which it represents. He holds provisionally that it antedates the Permian epoch.

THE PRESENT CONDITION OF SCIENCE IN THE HIGH SCHOOL.

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A new problem is at hand. How can it be solved? If it be open to experimentation, our usual scientific mode of attack is to set up suitable apparatus, perform experiments, record data and results, and from these, if possible, draw conclusions.

A problem which I have wanted answered for some time is this: What *is* the present condition of science in the high school? Can this be answered experimentally? I think it can. The apparatus has been set up, taken apart and reconstructed; the experiment has been in progress for many years, and results, though constantly changing, have been obtained, though few of these results have been recorded and few data are accessible.

Are not the conditions of scientific training in our secondary schools worthy of scientific analysis? Can we give them the proper consideration unless we have some data at hand? It would appear that we have relied long enough on general impressions and claims.

Be this as it may, I will record some data which I have recently collected—the present results of this experiment. Present, I say, for no doubt to-morrow they may change. But do we disregard temporary results in our experiments in the laboratory? Usually not, and frequently such results determine our methods for further experimentation. Why cannot our present results in this great problem of science help to make our future ones more definite? Certainly this has not been true in the past, for a subject could scarcely be in a more chaotic condition than is science in the high school at present. This, however, only helps to make the problem more interesting and the more worthy of our earnest and coördinated consideration.

Some time ago I sent the following questions to fifty of the larger high schools, principally in the Middle West.

1. Name of high school.
2. How many years of science are required for graduation in your high school?
3. What are the sciences required?
4. For how many years of science will credit toward graduation be given?
5. Which of the following sciences are taught in your high school, and in which years may they be elected?

Astronomy	Physical Geography
Biology	Physiology
Botany	Physics
Chemistry	Zoölogy.

A summary follows of the data received from forty-eight high schools in reply to these questions.

1. Amount of science required.

Schools not requiring science in all courses, 35 per cent.
Schools requiring one year of science in all courses, 46 per cent.
Schools requiring two years of science in all courses, 19 per cent.
Schools requiring at least one year of science, 65 per cent.

2. Of schools which require one year of science:

36% require physics.
32% permit a choice of any science.
14% require physics or chemistry.
9% require physiology and physical geography.
4% require physical geography.
4% require physical geography, botany, or physics.

Of schools which require two years of science:

44% require physics.
33% require physics or chemistry.
33% require botany or zoölogy.
22% permit a choice of any science, for one of two years.
11% require chemistry.
11% require biology.
11% require commercial and physical geography.
11% require botany and physiology.

3. Providing other requirements are met, the maximum number of years of science for which credit toward graduation will be given is as follows:

2	years	credited	by	4%	of	schools.
3	"	"	"	8%	"	"
3½	"	"	"	4%	"	"
4	"	"	"	41%	"	"
4½	"	"	"	8%	"	"
5	"	"	"	17%	"	"
6	"	"	"	12%	"	"
6½	"	"	"	2%	"	"
7	"	"	"	2%	"	"

4. The year in which any particular science may be elected is shown by the following table. These data represent 37 schools. Whenever in physics or chemistry a choice is given as between third and fourth years the subject is tabulated as belonging to the third year. The numbers represent percentage of the whole number of schools allowing election of the given subject in the year indicated.

Year / Subject	Biology	Botany	Zoology	Physiology	Physical Geography	Astronomy	Physics	Chemistry
1st year	33%	43%	13%	46%	62%	0%	0%	0%
2nd year	55	40	63	26	20	0	5	0
3rd year	0	9	13	11	5	25	50	68
4th year	0	3	0	7	5	64	42	29
any year	11	3	5	7	5	12	3	2

It will be noted from the above that there is the following distribution of preferences for particular years:

Physical Geography is given in the first year by 62% of schools.
Physiology is given in the first year by 46% of schools.
Botany is given in the first year by 43% of schools.
Zoölogy is given in the second year by 63% of schools.
Biology is given in the second year by 55% of schools.
Chemistry is given in the third year by 68% of schools.
Physics is given in the third year by 50% of schools.
Astronomy is given in the fourth year by 64% of schools.

These results, although very indefinite, suggest many interesting problems:

First, are we educating our children so as to fit them best for the period in which they are living? Few persons would dispute the fact that we are living in a scientific period, yet thirty-five per cent of our larger high schools do not require so much as one year of science of all pupils! This means that a large percentage of children receive no scientific training.

Second, it is apparent that in most high schools there is not a definite sequence of sciences. Science is not considered as a whole, but as a series of units. This often causes repetition, and perhaps sometimes gaps in the work. Text-books cannot be written so that they are suitable for use in any year in the high school, preceded by any or no science. Geometries are not written so that they may at will precede or follow high school algebra. Is it not possible to remedy this evil in science? Are not some of us willing to adapt our subject to the first or second year, rather than the third or fourth where we all think our specialty belongs!

Third, which shall be the required science? This will be

largely determined when the sequence of sciences is determined.

These and other similar existing conditions indicate, it seems to me, the fact that science teachers should be attempting to place the sciences in high schools upon a scientific basis. The amount of required science, the sequence of sciences, the science or sciences required, the sciences offered, etc., ought not to be a mere matter of chance or expediency as is so often the case at present; these things ought to be based upon accurate knowledge.

THE HIGH SCHOOL SCIENCE SITUATION.

By W. L. Eikenberry,

University High School, University of Chicago.

If it is true that periods of vigorous discussion are also likely to be periods of advance as well, we may hope to see early and definite results leading toward the solution of some of the problems of high school science. The variety of information developed in the present discussion is surprising. We have been told that there is among pupils a widespread distaste for science and that there is not; that the elections of sciences are increasing and that they are decreasing; that a certain subject will fail because the teachers are not prepared to teach it, while in another subject all the reported failures are due to the same cause and the subject will therefore ultimately succeed; that all the various sciences are but departments of one fundamental and all-embracing science, though as to which one shall lead there is an unfortunate difference of opinion. Different writers have different candidates for first place and singularly enough, in each case it seems to the science to which the writer has given closest study. Geography, physics, biology, and physiology are all candidates for the most prominent place on the ticket, and agriculture, domestic science, and chemistry are circulating petitions.

To an outsider there must appear great probability that we shall finally rediscover the fact that the divisions of the field of science are so poorly fenced off from each other that there is little difficulty in passing to any part of the field, regardless of the starting point.

The almost entire absence from the discussion of any tangible data bearing upon the questions at issue makes it hazardous to draw conclusions, but one may at least venture to suggest that

there is considerable uncertainty in the situation. The existence of this uncertainty is not wholly unavoidable. For instance, in the matter of number of elections of science in the high school it would appear that the obvious thing to do is to collect statistics of the actual number of elections in a series of representative schools for a number of years. The collection and analysis of such a series of facts as a method of investigating a question in pedagogy is peculiarly appropriate to science teachers since science demands the use of this method in the investigation of other problems.

The assertion of the general uncertainty of the science program is strengthened by the results of every investigation into the actual sequence of the sciences in high school curricula. Such investigations as those of Caldwell and of Hunter, published in School Science and Mathematics last year, and the work of Miss Weckel which appears in the current number, show that almost any science may be taken in any year of the high school, and that by the aid of the elective system practically any imaginable sequence may be secured. In other words, the practice of the schools demonstrates that any one of the sciences as now presented can be taught in any year of the course.

For a concrete illustration of these facts we may refer to the work of Miss Weckel, since it is easily available. By referring to the summary in section four of her paper it will be noted that the selection of particular years by particular subjects is quite irregular, ranging from forty-three per cent to sixty-eight per cent, the highest being chemistry in the third year. Sixty-eight per cent does not indicate a very close agreement as to the place of a study in the program, but the actual selection is less even than this. If we discard astronomy, which is not commonly given, we find that all the other sciences find their largest selection, so far as those who make the course of study are concerned, in the first, second, and third years. Now it is evident that if the position of each science were decided by chance alone it would appear in each year one third of the time, or $33\frac{1}{3}\%$. The real selection then appears to be more accurately measured by the excess of percentage over $33\frac{1}{3}\%$. This is $12\frac{2}{3}$ in the lowest case and $34\frac{2}{3}\%$ in the highest. These figures certainly do not demonstrate that we have arrived at any commonly accepted arrangement of the course of study in science.

It is true that each year is characterized by a slight perference

for a particular science, but if we inquire regarding the reasons for this preference the replies are not satisfactory. It is explained in part by the historical reason that in the days when laboratories were introduced into the schools it appeared to be an economic necessity to place the subjects which demand expensive equipment in the years in which the classes are small. The relation of physics to mathematics is another of the factors which have determined present practice; there are many others. None of the reasons advanced are universally accepted. Mathematics certainly is a prerequisite for the work in physics as at present organized but it has been shown that it is possible to so organize the subject that it can be introduced earlier; on the other hand it is quite possible to justify an arrangement of the courses in physiography and biology such that they demand physics and chemistry as a prerequisite and profit very much from certain features of the work in mathematics. Whether such a modification of these subjects would be desirable is quite another question and one upon which we have little information. The proper sequence of the sciences in the course of study is a matter that cannot be decided wholly by a consideration of the theoretical relations of these fields of knowledge to each other but must rest mainly upon a determination of the needs of the pupils at different stages of their development and the suitability of various sorts of scientific material as instruments in advancing their development. We have scarcely begun to learn how to collect data upon this point.

The problem that lies before us is not that of a contest between two subjects for a certain position; the whole science curriculum of the high school is our problem. Since the work of the first year is necessarily fundamental as respects all that follows and since it is frequently required of all pupils it is being first attacked, and the discussion may confidently be expected to continue for some time. Just why such great apprehension should be occasioned, outside of text-book circles, by any proposals for experimentation in the first year is not clear. It is in fact easy to recall the time when all subjects competed for the coveted place in the later years. The principal contest at present is between physiography and general science. It is asserted that general science is foredoomed to failure because no unifying principle can be found. Prophecy is traditionally dangerous, and particularly so in this case. It is a bold man who will in the face of the unifying tendencies of all modern research deny the essential unity

of all science; those who are able to include the universe within a single science should not be the first to deny this unity.

The difficulty of securing teachers who are equipped to instruct in such a broad course does not seem insuperable. It may be recalled that many of the greatest names in contemporary American science are the names of men who not many years ago occupied not a chair of science but a whole bench, and in that capacity developed some of our best younger students of science and materially assisted in advancing the cause of science. True, our smaller colleges did not at that time offer much science, but they offered a good deal more than the present high school freshman is able to assimilate. There are plenty of men in similar positions in the smaller institutions at present. Such conditions may not make for efficiency in research, but the quality of the instruction is not seriously affected as is shown by the success of the students sent up to the greater institutions. There are also many teachers of broad scientific training and sympathies in high school faculties. In any case the state of unpreparedness can scarcely be worse than is asserted to be found in many of the sciences at present, and the need for broader training will be met as it arises by the institutions which prepare teachers of science.

The gist of the whole thing is that the matter cannot be settled by rhetoric. Facts ascertained by experiment are the final recourse. Upon purely theoretical grounds it would appear that there are certain logical advantages in an experiment which does not commit itself in advance to any particular field of science but draws its materials from all sciences with prejudice to none, as compared with an experiment which proceeds by adding extraneous material to a selected science already very well organized. In the latter case natural and unconscious conservatism throws the burden of proof upon the new material with consequent limitation of experimentation and prejudice of results. However, either method if pursued faithfully and scientifically should lead to the same result. What that result will be should be determined by experiment and not by prophecy. The introduction into courses in physiography of material from the other sciences, now commonly practiced, indicates that one of the results to date is a closer approximation of the two ideas.

Every form of educational experiment which has a rational basis and is conducted scientifically should be welcomed; those teachers who fail to record the results of their experiments and

to give to the world the data secured are thereby failing to assist in the solution of the problem. It may be hoped that the present tempest will be succeeded by a period whose dominant characteristic will be scientific investigation. Every class is a more or less instructive experiment and should be treated as such.

If such conditions as these shall exist we may hope that within a few years we shall be able to reach fairly definite conclusions upon several difficult problems. In the meantime we shall not be materially assisted by the polemics of those who are not teaching these subjects in the high schools, or of those who are doing so.

A WALL FORM OF BENDING APPARATUS.

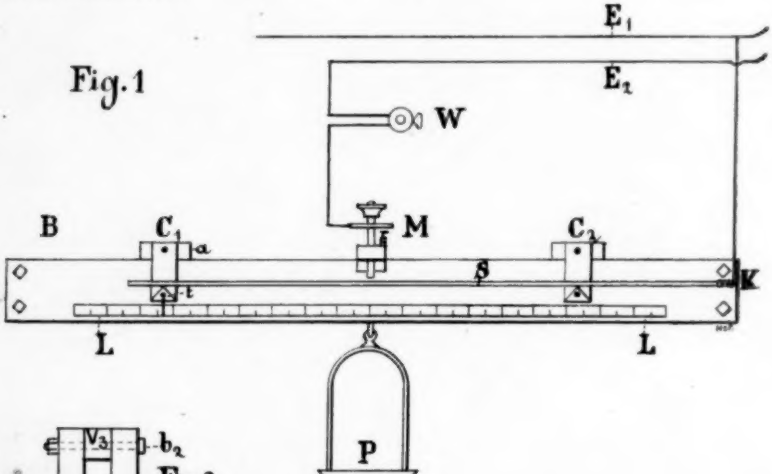
By C. L. Vestal,
High School, Keokuk, Ia.

Most laboratory apparatus is made with the idea that it is to be assembled by the student. There are frequently cases, however, in which the value of the experiment would be greatly improved by relieving the student of this work. Especially is this true where the apparatus as set up on the table is unstable and very easily disarranged. This condition makes the student afraid that his experiment will not succeed and prevents him from concentrating his attention on the principle. It is therefore desirable in such cases to have a permanent piece of apparatus which can be rigidly attached to a table of its own and remain there. Then in working with it the boy has no fear that his apparatus will become dislodged and make him all the work of setting it up again.

A case in point is the working out of the laws of bending and of Hooke's law by means of bending. Most of the table apparatus for this purpose, which has come under the writer's notice, has not been satisfactory. It is built in such a way that any jar or side force will disarrange it. This is very discouraging, to say nothing of the loss of time. After trying various schemes for making it stable and finding them all more or less vexatious and unsuccessful, the writer finally devised a wall form of this apparatus, which has now been in use several years and has proven entirely satisfactory. A line drawing and a front view photo are shown herewith.

The apparatus is nearly all of hard wood. Referring to Fig. I, B is a walnut board—any other hard wood will serve, but must be quite well seasoned. B is four feet long and four inches wide and three-fourths of an inch thick. In a square-cut notch of the proper size, about two by two inches, there is set an ordinary heavy base micrometer screw, M, reading to one one-hundredth of a millimeter.

Fig. 1



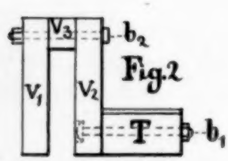


Fig. 2

C_1 is a moving carriage, made up as shown in Fig. II, which is a side view. It is all of oak blocks, of course perfectly seasoned. v_1 and v_2 are exactly similar oak strips, one and one-half inches wide, four inches long, and three-fourths of an inch thick, separated by the block v_3 of equal dimensions, but having its long axis at right angles to that of the two it separates. It is indicated by *a* in Fig. I, and is the sliding block of the carriage. T in Fig. II is a side view of the triangular oak prism seen at *t* in Fig. I. It is about two inches long, and the bases are equilateral triangles measuring one and one-half inches on a side. The whole is held together by the bolts, b_1 and b_2. As shown, the head of b_1 is countersunk. Projecting a short distance below the bottom of the carriage is a piece of small knitting-needle, to indicate the position of the upper edge of the prism on the meter stick, L.

With one exception, to be noted, the other carriage, C_2 in Fig. I, is similar in every respect to the one described. Both are instantly adjustable anywhere along the supporting board.

The method of operation is as follows:

The rod whose bending it is desired to investigate is laid upon the prisms after these have been adjusted to give the distance desired between the points of support. The pan P is then hung on the rod about midway between these points by a brass hook made of a thick strip. The micrometer screw is then adjusted for contact with the rod and this reading is taken as the zero position. Thus the weight of the pan need not be considered.

As shown, contact is determined electrically. E_1 and E_2 are lines to the battery. W is a watch-case receiver of 75 ohms resistance. One connection with the apparatus is made by means of a binding-post on the base of the micrometer. The other is at *k*, the end of a brass strip, S. The two upper sides of the prism of the carriage C_2 are covered with a piece of thin sheet brass, and around the upright to which the prism is attached is another narrow strip of sheet brass making sliding contact with the strip, S, and also attached to the sheet on the prism. Thus it is seen that when a metallic rod is in place for being tested there is a complete circuit, of which the rod is, of course, a part, when the lower end of the micrometer screw makes contact with the rod. If the rod is wood a small tack can easily be driven a little way into it at the middle, a fine copper wire attached to this tack, and the end of the wire slipped behind the brass strip, S.

This apparatus is fastened to the wall at a convenient height, and is thus out of the way, as it projects less than three inches into the room. It has the advantage of being always ready, and the greater added one of being rigid. It is strong enough for testing weights up to twelve kilograms.

MEXICAN SODA BEDS.

Certain soda beds on the Bay of Adair, in the Altar district, Sonora, have been leased to concessionaires by the Mexican government, subject to the approval of the Department of Fomento. The tract of soda land is on the shore of the bay and comprises nearly ten thousand acres. Construction of a soda plant must start within six months.

HOW TO HARDEN COPPER.

Copper may be hardened by the use of a mixture of alum and arsenic. Two pounds of alum and eight ounces of arsenic are used for each forty pounds of copper, the alum-arsenic mixture being stirred into the molten metal for about five minutes before pouring.

A DISSECTED SIPHON.

By J. Edwin Sinclair,
Barringer High School, Newark, N. J.

In order to simplify the explanation of the principle of the siphon the following piece of apparatus was devised. I have never heard of its being presented in the following way and it may be of interest to readers of School Science and Mathematics.

Two tubes of unequal lengths were taken and on one end of each was placed a piece of rubber tubing three inches long. Each piece of tubing was then closed by means of a pinch-cock. The glass tubes were completely filled with water and then inverted in receptacles containing water, the long tube being placed in water at a lower level than that in which the short tube was placed. The tubes were clamped in such a position that the upper ends of the rubber tubing on each tube were at the same level. They were then joined by a short piece of glass tubing filled with water containing an aniline dye, care being taken to remove the air in the tubes above the clamps by first filling them with water. The siphon was then complete and set in operation by releasing the pinch-cocks.

Very few pupils after an explanation of the mercurial barometer will fail to understand that the atmosphere is supporting the column of water in each tube before they are joined. Knowing the extent of the atmospheric pressure they realize that there is a tendency to push more water up each tube, but that this force decreases as the height of the water column increases. But since one tube is shorter than the other the upward force is greater in that tube. The joining of the tubes does not affect the pressure in either tube since the joining tube is horizontal. Evidently the water will flow in the direction of the stronger force. The object of using the colored water was to have an indicator of the direction of flow the moment the pinch-cocks were removed.

A SEARCH FOR POTASH.

The amounts appropriated for the work of the United States Geological Survey for the fiscal year ending June 30, 1912, include an item of $40,000 "for chemical and physical researches relating to the geology of the United States, including researches with a view of determining geological conditions favorable to the presence of potash salts." It is understood that one-half of this appropriation will be devoted to the potash exploration.

DAYTIME WORK IN ASTRONOMY.

By Sarah F. Whiting,
Wellesley College.

Since no instrument has been invented capable of piercing the clouds, work in observational astronomy has always depended on the caprice of the weather. For this reason astronomy has been a vigorous discipline for the few; it has never taken its place beside the other sciences as a training in the scientific method for the many. Botany, chemistry, physics, psychology, zoölogy, all now require an allowance in the school or college program of fixed hours for work on the part of the student. Astronomy alone adheres to the old lecture method with a little evening star gazing.

This science should now have its laboratory, its proper apparatus, its fixed hours for daytime work, its laboratory demonstrator. There is no longer ground for the old excuse that there is lack of material, since celestial photography now furnishes for daytime study perfect representations of sun, moon, planets, and stars. The ephemeris, star charts and globes, star catalogues and plotting paper can be used to advantage by the student; and many illustrative pieces of apparatus have been invented which greatly aid to awaken the scientific imagination.

We need to remember, however, in criticising the tardiness of astronomy, that the laboratory method is comparatively new, hardly two generations old. Many of us have doubtless heard distinguished chemists tell of the white heat of enthusiasm which characterized the work in the first students' laboratory of chemistry in Giessen, that rude, barnlike building where Liebig presided. It is fitting that it should have been lately purchased by the chemists of Germany to be preserved as a witness to an epoch-making pedagogical departure.

The life of the late Lord Kelvin relates his difficulty in preparing for a professorship in physics, the scant opportunity open to him for learning to handle apparatus. Once installed at Glasgow University he initiated in an abandoned wine cellar the first students' laboratory in physics. Students' laboratories in physics in America started by one who has since become a great astronomer, had not a sure place in the colleges until 1880 nor in high schools until 1895.

There is special need of the rigid discipline of the scientific method in astronomy, since many elect it because they desire information concerning things beyond the ordinary ken which

this ancient science is supposed to give and they think a lecture course will be easy. The student who thus vaguely wishes to soar into the skies feels his wings clipped by finding that gazing through a telescope with exclamations of wonder and learning the names of the stars and talking about the nebular hypothesis is not astronomy; that by handling globe and chart he must become grounded in what the old astronomers called the "Doctrine of the Sphere" as a preparation for the study of the open sky. Moreover it is as true in this science as any other that "sharpening the pencil sharpens the eyes," and that a good drawing is a test of knowledge.

But it cannot for a moment be thought that the daytime work here advocated can take the place of observations in the open, of the sun by day and the moon and stars by night. All is but a means to an end, and the student should never be permitted to bend over chart and plot till he fully realizes that it is a strip of the sky overhead which he is considering. After daytime preparation, however, a short time out of doors, often under circumstances of more or less uncontrollable discomfort, accomplishes wonders.

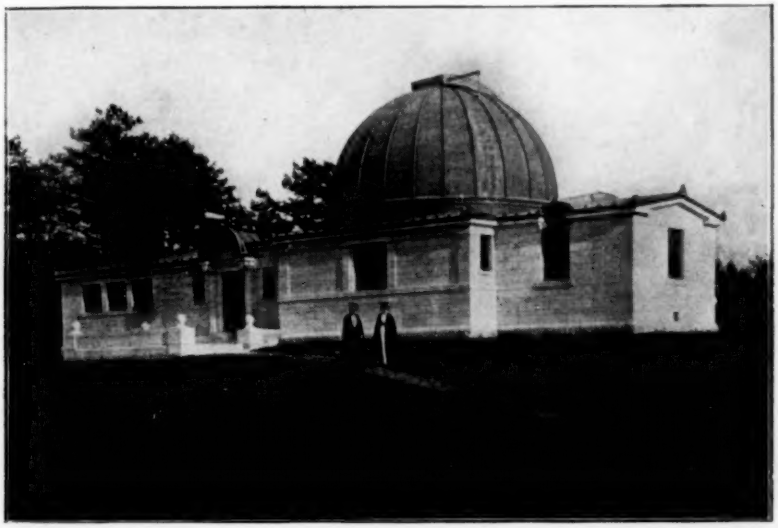
Since astronomy is the only science dealing with matter, which takes the mind off this little planet, and gives those larger conceptions of time and space which stretch the mind and furnish proper perspective for other subjects, everyone should know something of it and many never see college halls. The high schools should take up the subject more generally, and the colleges should furnish properly trained teachers.

The ideal college equipment for astronomy is an observatory near enough to the centers of student life to be accessible, equipped with the best instruments for every observation, with a large laboratory where students meet in sections of about fifteen for the accustomed consecutive hours of individual work under the eye of a demonstrator. There must be, moreover, a collection of photographs, charts, catalogues, and illustrative instruments for the students' own handling. For this kind of work the management of both schools and colleges must recognize that the same allowance of time and money for laboratory instruction is necessary as in the other sciences.

The writer has been fortunate in enjoying this enlightened cooperation. The Whitin Observatory of Wellesley College, dedicated in 1900, had only the ordinary rooms and equipment of an observatory for evening work. Daytime work by the students was started and the interest manifest caused the generous

donor of the observatory to permit it to be doubled in size in 1906, by which a large laboratory room with a spectrum laboratory beneath it was provided.

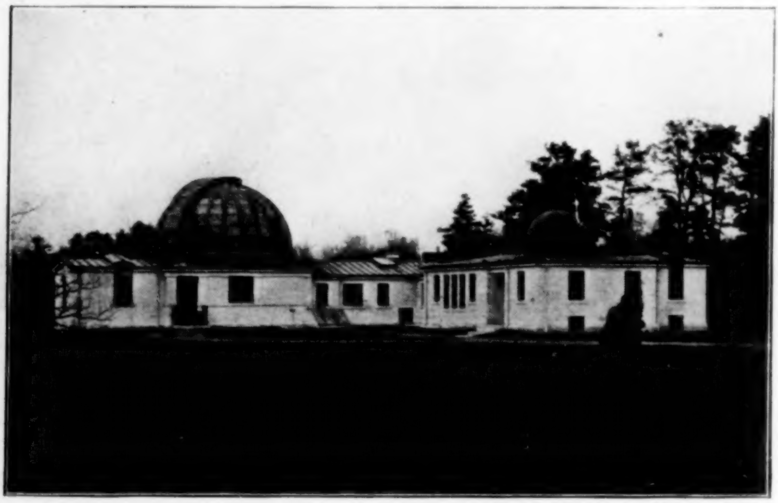
It is not the purpose in what follows to describe in detail the exercises given from week to week but only to illustrate the methods pursued.



The first set of daytime exercises is planned to prepare the student for rapid evening work in identifying the constellations, the great circles of the sphere and the coördinates for fixing the places of the stars. After learning the Greek alphabet, a short piece of work for a high school or college student, the "catch figures," that is, the figures among the stars which most easily attract the eye, should be outlined on the atlas, for the circumpolar constellations, the constellations of the zodiac—the highway of the planets—and of the arch of the Milky Way. With this framework the other asterisms are soon filled in.

The next fundamental to make clear is the system of coordinates used in star catalogues. The exercises planned for this may have as a by-product the discovery by the student himself, as by Hipparchus of old, of the fact of the procession of the equinoxes. A list of the twenty brightest stars is made out and convenient 12 inch globes, one for each two students, are provided, with paper strips graduated to degrees. The right ascension and declination of each star is recorded by the student. That he may learn to handle a star catalogue, one of the Har-

vard Observatory Catalogues for the brightest stars for the epoch 1900 is given him, and from this he records in parallel columns the coördinates of the same stars. Most globes are made from the famous British Association Catalogue of 1850. The students are told this fact, and when they find on inspection that the readings from the catalogue are systematically greater than those from the globe they can only infer that all the stars have moved, or that the zero point has moved. Thus, from his own observation, the student is introduced to precession.



For further work in conceiving the motions of the celestial sphere as a whole, besides the globes, a recent device, the Constellation Finder, has been found useful. This instrument combines the principle of the planisphere and an equatorial telescope mounting. An arrow which can be pointed at the constellation is set in right ascension and declination like a telescope. This can be turned through a complete revolution and show the place of the constellation at any time of day as well as of night. With one of these in the hands of each student much can be learned of the motions of the stars and of sidereal time.

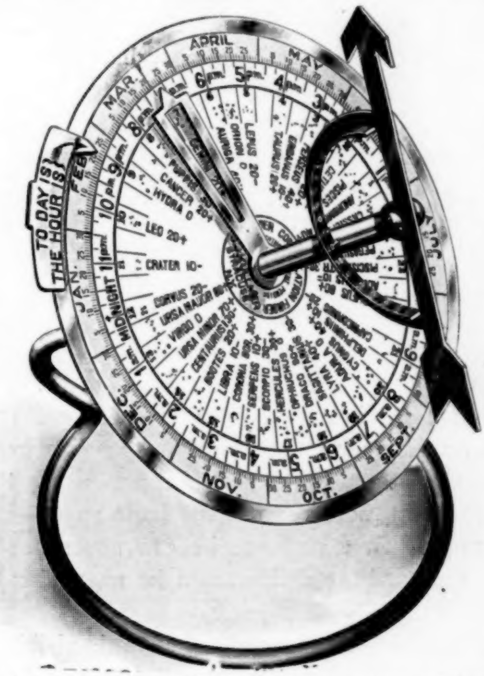
The celestial sphere with its circles of reference and the positions of the principal stars once learned, the next series of daytime exercises should assist the imagination to picture the motions of the earth and its relations to the sun, which cause the phenomena of daylight and twilight, heat and cold. Here earth science and astronomy have much in common. While an apple or an orange, a knitting needle and a candle, when nothing else

is available, may help to make clear the conditions which cause the succession of the seasons, mechanical devices used by a skillful demonstrator are very useful.

One of the best is Gardner's Season Apparatus. This cannot well be duplicated for students to handle and by most teachers it

Kulliner's Constellation Finder.

The disk is set to the elevation of the equator at the place. By bringing the time and date together as in a planisphere, the constellations are brought into proper position with reference to the horizon. The opening is set to enclose the desired constellation beside which the declination is given, to which the arrow can be set.



would be used in the lecture room. It is better to demonstrate before the small laboratory divisions, each student with notebook in hand in which to write answers to questions as the apparatus is manipulated. By this method a clear conception is gained of the movements of the circle of illumination and of the movement of the oblique ray northward and southward. With a slate globe the circles and tropics, traced by the sun's perpendicular ray and the sun's spiral path from the equator north and south, can be marked with chalk.

The sunboard of Professor Good described in this journal, and the sunboard and hemispheres of Professor Robert Willson are both of value but their use depends on the presence of sunlight. Observations with Professor Willson's sunboard, at different seasons of year, can sometimes be taken by a janitor or anyone who can command consecutive time on a sunshiny day and the papers containing these observations can be duplicated and used by a class to plot the diurnal path upon the hemispheres. (*To be continued.*)

THE HORIZON DISC AS A CONNECTING LINK IN THE STUDY OF SEASONS.

By Joseph F. Morse,
Hyde Park High School, Chicago.

It is safe to say that most teachers of physical geography find the subject of seasons the most difficult and least satisfactory part of their work. Pupils will seem to understand the subject, and will give correct verbal explanations; but a little probing for the ideas back of their words usually shows their knowledge to be vague and superficial.

The chief reason for such unsatisfactory results in the teaching of seasons is to be found, not in the inefficiency of the teacher, nor in the stupidity of his pupils, but in the wrong method of presenting the subject. It is the universal custom to demonstrate seasons from globes, on which the limit of sunshine at different seasons of the year is shown. This way of presenting the subject is entirely wrong pedagogically, because it connects in no way with the actual or possible experience of the pupil. In viewing a sunlit globe, representing the earth, the pupil is looking at the earth and sun from space—a position he can never occupy. In experience he can never see but a minute portion of the earth at a time, and he must always view the sun from the earth.

Viewed from the earth the sun is visible only when it is above the observer's horizon in its daily circuit of the sky. The immediate cause of seasons, and the only cause that can become a matter of observation and experience, is the course of the sun with reference to the horizon. To know seasons as experienced, one must know the effect of latitude in determining the sky path of the sun. He must be able to picture to himself approximately the diurnal arc of the sun as seen from different latitudes at different seasons of the year.

The usual globe demonstration of seasons gives little help in picturing the sun's movements as seen by an observer on the earth. It shows in a general way the direction and altitude of the noon sun for different latitudes and seasons, but does not locate the rising and setting points of the sun—unless the pupil is mathematician enough to determine this by trigonometrical calculation. Three points must be known to fix a circle in the sky—as well as elsewhere. With only the noon position of the sun known, and its rising and setting points uncertain, the pupil

has not sufficient dàta for forming a mental picture of the sun's diurnal arc at different seasons and latitudes. One who studies seasons from a sunlit globe knows that increase of latitude lessens the altitude of the noon sun, and lengthens the days in summer and shortens them in winter; but where the sun is during either the long days of summer, or the short days of winter, except at noon, he cannot say. Ask pupils who have studied seasons in the usúal way whereabouts in the observer's sky the sun is during the weeks or months of continuous sunshine in the summer of polar latitudes. Their answers will show how completely they have failed to image the sun's course as seen from different latitudes—how little they know of seasons as actually experienced.

The writer is not claiming that seasons can be fully demonstrated without showing pupils earth and sun relations as viewed from space; but only that the view from space must be presented in a way to connect with the possible experience of the pupil.

This can be done by using a "horizon disc." Have the pupil pin a small pasteboard disc, representing the seemingly flat portion of the earth's surface enclosed by an observer's horizon, to a hand globe, at different latitudes, and rotate the globe in right position to the sun, or artificial light, for the equinox and two solstice dates. Across the disc should be drawn two diameters at right angles to each other, to represent the north-to-south and east-to-west directions, and the circumference of the disc should be further subdivided—say into 15° spaces. Care should be taken to pin the disc to the globe with the north-to-south diameter over a meridian.

By imagining himself at the foot of the pin the pupil can trace the approximate course of the sun as seen from each latitude considered. The place of sunrise and sunset will appear from the direction taken by the pin's shadow when first and last seen on the disc in the course of the globe's rotation. The varying height of the noon sun will be indicated by the varying length of the pin's shadow in the noon position of disc.

A horizon disc, used in this way, enables one to view the earth from space without losing contact with the earth. He can interpret what he sees from space as if it were seen from the earth. Without the horizon disc the study of earth and sun relations from space has no point of contact with the possible experience of a dweller upon the earth. Such a study of seasons takes the pupil clean off the earth, and leaves him very much in the air—

or space, rather—when it comes to picturing the sun's course as seen from different latitudes on the earth. The horizon disc bridges the chasm from the space view to the earth view, and thus connects the ultimate and real cause of seasons with possible human experience.

MINERS' CIRCULAR.

This is the first of a series to be written in plain, non-technical language for the benefit of the miner, has just been issued by the Federal Bureau of Mines. It contains the names of the permissible explosives tested by the bureau at its Pittsburg station up to November 15, 1910, and gives precautions as to their use. Permissible explosives give a short and relatively cool flame that is less likely to ignite inflammable gas or coal dust than is the longer and hotter flame of dynamite or the longer and much more lasting flame of black powder. Because they can be used with greater safety, permissible explosives have taken the place of other explosives in many coal mines in the United States during the last two years and their use is increasing rapidly.

To reduce risks in storing, thawing, and handling explosives at coal mines, some thirty or more precautions are urged by the Bureau of Mines.

SIMPLE WAY OF PROJECTING A DARK-LINE SPECTRUM.

By Ignatius B. Kircher.
Marquette University, Milwaukee.

I suppose a great many instructors in physics have often longed, like myself, for a simple and reliable way of projecting a dark-line spectrum for lecture purposes. I think I have hit upon a method both simple and reliable. I have not, however, taken the trouble to read up the literature of the subject and, therefore, do not know whether my scheme is novel or already well known. I give it for what it is worth. Arrange an electric arc, prism, and lenses in the ordinary way for projecting a spectrum, but insert into your arc-lamp flaming carbons of the variety whose line-spectrum you desire. This is the whole scheme—easy and simple to execute.

BORAX IN THE UNITED STATES.

Mines all in California.

California produces all the borax mined in the United States and is now supplying nearly all the domestic demand. The principal mine is in the Death Valley region, in Inyo County. Another mine is in Los Angeles County.

The mineral mined is colemanite, or borate of lime, most of which is shipped crude to Alameda, Cal., or Bayonne, N. J., for refining.

About half the product is consumed in enameling kitchen ware, but new uses for borax are found every year.

A leaflet on the production of borax in 1909, by Charles G. Yale, has just been published by the United States Geological Survey as an advance chapter of its report "Mineral resources of the United States, calendar year 1909."

THE MANUFACTURE OF PAINTS AND PIGMENTS.[1]

By Edward C. Holton,
Chief Chemist Sherwin-Williams Company.

Broadly speaking, any material, whether in the form of a dry powder, a paste, or a liquid which can be readily applied to the surface of an object for the purpose of decorating or protecting it, may be called a paint. It is better usage, however, to classify the dry powders used in paints as "pigments," and to consider a true paint as a mixture of a pigment and a liquid called a "vehicle," in which the pigment is suspended.

Many substances and combinations have been used as vehicles. Water solutions of gums, glues, casein, honey, sugar, etc., serve as vehicles in water paints.

In enamel and varnish paints, lacquers and varnishes are used as vehicles.

A lacquer is a solution or partial solution of a resinous substance or its equivalent in a volatile solvent which leaves a more or less hard and lustrous film upon evaporation of the solvent. A varnish is a solution or partial solution of a resinous substance in a fixed oil and a volatile organic solvent. The drying of a varnish is brought about by the evaporation of the solvent and the oxidation of the oil.

A dyestuff in solution or a finely ground pigment in suspension in water or aqueous binding material, or in volatile organic solvents, or in oils, or in lacquers, or in varnishes, may be considered either a *stain* or a *colored lacquer,* or a *colored varnish,* according to the conditions of its use.

Beeswax and other waxes have been used as vehicles.

Sunflower Oil, Poppyseed Oil, Walnut Oil, China Wood Oil, Fish Oil, Soya Bean Oil, and many other oils have been used as vehicles, but the one great paint vehicle of the world is "Linseed Oil."

Linseed Oil possesses the property of slowly drying to a tough, elastic film when exposed to the air in thin layers. This drying is much hastened by introducing into the oil small amounts of certain oil soluble lead and manganese compounds. One method is to heat the oil in kettles, with small amounts of oxides of lead and manganese, producing what is called "boiled oil." This boiled oil dries much more quickly and satisfactorily than untreated oil. Another and usually better method is to prepare a

[1]Read before the Chemistry Section of the Central Association of Science and Mathematics Teachers, Nov. 25, 1910.

liquid dryer by heating oil or oil and certain resins with lead and manganese compounds and dissolving the resulting product in spirits of turpentine or other suitable solvent. This liquid dryer when added to raw linseed oil greatly accelerates the drying, and produces a tough, lustrous film.

Aside from whitewash, which is slaked lime suspended and partially dissolved in water, and the kalsomines, which are glue and casein water paints, the greater part of the world's paint contains linseed oil, and it is linseed oil in its simplest form which we will first consider.

The manufacturer of paint in a small way seldom prepares his own pigments and vehicles. He purchases these from the manufacturers or importers who have gathered them in from all quarters of the globe. Strictly speaking he is a paint mixer and grinder. He mixes his pigments and vehicles in mechanical mixers to the consistency of a heavy paste and this paste is then run through a mill which grinds it to a fine, smooth paste. This paste may be filled into packages ready for sale or it may be run into a thinning tub, more vehicle added and the whole mixed to a uniform consistency ready for use, and then it is filled into packages ready for sale. This seems very easy. Buy oil, driers, pigments, mix, grind, and sell.

If a paint grinder could be certain that his oils would always be pure, his driers of uniform strength and his pigments unvarying in color, tone and tinting power, he would be spared much trouble, for after once having made up his formula for his various paints he need never vary them until something new should be demanded by the trade.

Unfortunately there is much lack of uniformity in the pigments, oils and driers coming to the paint grinder, and he must have a force of men ever on the alert, watching, testing and classifying his raw materials and modifying his formulæ so that his finished product may be up to standard in every way. As the business grows the troubles increase until at last it not infrequently happens that he is forced little by little into the manufacture of many of the various pigments and vehicles which he formerly purchased.

Thus in time a paint grinder may become a varnish maker, an oil refiner and crusher, a chemical manufacturer, a miner of ore, a smelter of metals, a corroder of white lead, etc.

A paint business may be built up in another way. A miner of ore may become a smelter of lead, the smelter may become a

corroder of white lead, the corroder becomes a grinder of paste lead, and from that to a general paint manufacturing business is an easy step.

In the limited time at our disposal it will be impossible to do more than briefly allude to the types of pigment.

Nature has provided us with many pigments which require but little treatment to prepare them for use. Some of these are the various colored clays, iron oxides, hydrates, silicates, etc. These are red, yellow, green, and when manganese is present, of varying shades of brown. These are known as red, yellow, and green ochres, siennas, umbers, etc. They merely have to be mined, quarried or dug, sorted, pulverized, and bolted or water floated, and dried to fit them for use. These same natural pigments may be further changed in color, tone and strength by calcination.

Natural black pigments are made by pulverizing bituminous shales and graphite. Natural white pigments are prepared in similar way from barytes, kaolin, gypsum, asbestos, serpentine dolomite and chalk. Most of these however possess but little opacity.

The most brilliant colored pigments, the most intense black, and the most opaque white pigments are not found in nature in commercial quantities, and must be prepared by chemical processes.

The manufacture of Old Dutch Process White Lead and American Process Zinc Oxide will be illustrated by lantern slides.

We can illustrate the manufacture of brilliant colored mineral pigments by precipitating some chrome yellow, chromate of lead and prussian blue, a ferric ferrocyanide; and chrome green by mixing the chrome yellow and prussian blue.

We can illustrate the manufacture of an organic dyestuff pigment by precipitating the so-called para-nitraniline red.

The manufacture of a black can be illustrated by holding a cold porcelain over a candle flame or by making charcoal from wood or bones.

Arrangement of Paint Factory.

Receiving	Grinding—filling as paste
Sampling	Thinning—filling as liquid
Testing	Labeling
Storing	Packing
Mixing	Shipping

AN INORGANIC PREPARATION.

By Nicholas Knight,

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The Niagara limestone, one of the great formations of the geologic past, is accessible in many localities. The composition may vary in different sections of the country, but throughout northeast Iowa, where there are extensive outcrops, the rock is quite a pure dolomite. An analysis shows its composition as follows:

$CaCO_3$	about	55 per cent.
$MgCO_3$	about	43 per cent.
SiO_2	about	1 per cent.
Fe_2O_3 and Al_2O_3	about	1 per cent.
		100 per cent.

The experiment consists in separating the magnesium from the other constituents and changing it to magnesium sulphate or Epsom Salts.

The method is as follows:

Five grams of the fine rock powder are dissolved in hydrochloric acid by gently warming. The insoluble residue, mainly silica, is removed by filtering, and the filtrate is treated with a few drops of fuming nitric acid to oxidize the iron to the ferric condition, and the iron and alumina are precipitated from the boiling solution with a slight excess of ammonia. The filtrate from the iron and alumina consisting of calcium and magnesium chlorides is evaporated to dryness on the water bath and then changed to the sulphates by successive additions of pure, dilute sulphuric acid, being careful to avoid an excess. Water is added, and most of the calcium sulphate can be filtered off as it is soluble in the proportion of about four hundred parts to one. The magnesium sulphate can be separated from the remaining portion of the calcium sulphate by crystallization. To avoid an excess of ammonium salts which might interfere with the success of the experiment, not quite a sufficient amount of hydrochloric acid to dissolve the original rock powder may be added. If the ammonium salts seem to interfere, they may be removed by ignition. The equations that express the principal reactions are the following:

$CaCO_3+2HCl=CaCl_2+H_2O+CO_2$

$MgCO_3+2HCl=MgCl_2+H_2O+CO_2$

$FeCO_3+2HCl=FeCl_2+H_2O+CO_2$ or

$Fe_2O_3+6HCl=2FeCl_3+3H_2O$

$FeCl_2+HCl+HNO_3=FeCl_3+H_2O+NO_2$

$FeCl_3+3NH_4OH=Fe(OH)_3+3NH_4Cl$

$CaCl_2+H_2SO_4=CaSO_4+2HCl$

$MgCl_2+H_2SO_4=MgSO_4+2HCl$

The dolomite powder may also be dissolved in pure dilute sulphuric acid, and the silica, iron and alumina removed as before. This will save time by avoiding the necessity of changing chlorides to sulphates.

Again, after dissolving the powder in hydrochloric acid, and removing the silica, iron and alumina, the calcium can be removed with ammonium oxalate, the filtrate evaporated to dryness, and the magnesium changed to sulphate by successive additions of sulphuric acid. The experiment is easily within the reach of high school students, and they become very much interested in thus preparing Epsom Salts. By it they also obtain a glimpse of the method of making a quantitative analysis of this and similar rocks.

COLORADO.

Colorado contains no important copper district, its main output of copper being incidental to the recovery of other metals. It will probably show no great change from the output of 11,485,631 pounds in 1909.

APPROPRIATIONS FOR THE WORK OF THE UNITED STATES GEOLOGICAL SURVEY.

Most of the appropriations for the work of the United States Geological Survey are included in the great Government supply bill known as "An act making appropriations for sundry civil expenses of the Government," popularly called the "sundry civil bill." The bill for the fiscal year closing June 30, 1912, contains appropriations for Survey work amounting to $1,205,520. The principal items are as follows:

Topographic surveys	$350,000
Geologic surveys	300,000
Mineral resources of the United States	75,000
Chemical and physical researches	40,000
Geological maps of the United States	110,000
Gaging streams, etc.	150,000
Surveying national forests	75,000

The bill also appropriates $165,000 for printing and binding Survey reports, to be expended by the Public Printer.

In addition to these amounts the sum of $100,000 for surveys in Alaska was included in the urgent deficiency act, approved December 23, 1910, and the sum of $37,400 for rents was appropriated in the "legislative bill," making a grand total of about one and a half million dollars.

SIGNIFICANCE OF THE HISTORY OF MATHEMATICS TO THE TEACHER OF ELEMENTARY MATHEMATICS.[1]

BY ALVA WALKER STAMPER, PH.D.,
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One way for the teacher of elementary mathematics better to direct the powers and understand the capabilities of his pupils, is to learn first something of the tendencies and difficulties of the race in its mathematical development. It is not to be expected that the pupil will or should repeat all the errors of commission and omission made by his remote ancestors nor that he follow the devious paths which led them to mathematical truths; but a review of the history of mathematics and of its teaching shows certain well marked correspondences between the development of the race and of the individual. Hence, a knowledge on the part of the teacher of the historical development of the subject matter of mathematics and of racial tendencies and difficulties in this development should give a good perspective for present teaching.

Mathematics had a practical beginning. Nations counted and made computations without and with symbols before the science of numbers (the *arithmetica* of the Greeks) was undertaken. Algebra was largely an outgrowth of the arithmetical problem. The logical geometry of the Greeks was preceded by the practical work in mensuration and surveying of the Egyptians and there is good reason for believing that the Greeks were stimulated in their efforts to organize the science of geometry by their interest in astronomy. There is small wonder that it is being realized to-day that pupils of both the elementary and the secondary school should get their start in mathematics through work that is essentially practical to them.

The tendency to hold to the special is noticed in the mathematical development of the race. In their use of fractions the Egyptians employed those with numerator 1, the Babylonians with denominator 60, and the Romans with denominator 12. These nations probably made less progress in their study of fractions than if they had handled freely the general fraction. The tendency to hold to the special has been marked in the history of algebra. The early Greeks, for example, solved separately by geometric means the several forms of the quadratic equation. It was approximately 1,000 years before the general form of the

[1] Read before the Mathematics Section of the California Teachers' Association, December 29, 1910.

quadratic was recognized and used by the Hindus. In the early development of geometry separate proofs were often given by the Greeks for the various kinds of figures of a certain class, in which there was no logical or pedagogical gain. Since the race was relatively slow in reaching a conception of the general, it is well to consider in teaching the probable difficulties of the pupil in this connection.

Teachers should not be surprised that pupils tend to assume much in attempting the proofs of mathematical propositions. Euclid, himself, was not blameless in this regard and neither were less prominent writers of from 1,500 to 2,000 years later. Some of our recent texts in geometry are following historic precedent (and wisely so) in assuming the truths of certain early self-evident propositions.

The high-school teacher should not be discouraged if pupils find difficulty in understanding the symbolic language of mathematics. The race did not readily adopt a comprehensive number symbolism. The symbolic form of the equation was the result of a slow development and the recognition of negative roots of an equation was delayed centuries after the solution of quadratics had been begun.

Some topics in mathematics have not always been easily or satisfactorily handled. The study of the incommensurable, for example, has apparently always given difficulty, as shown in the history of the teaching of geometry. Euclid recognized the unsatisfactory treatment of incommensurables in relation to the theory of limits, and substituted a treatment of ratio and proportion whose definitions eliminated these difficulties. Later texts abandoned Euclid's treatment of proportion for the algebraic method, notably books printed on the continent and intended for use in higher secondary schools. These texts, some of which appeared as early as the seventeenth century, generally ignored the incommensurable case.

While it is fair to assume that certain tendencies of the race are to a great extent duplicated in the mathematical development of the individual, it is taking too much for granted to suppose that the mathematical development of the individual should necessarily follow the lines of development of the race. Thus, because the race found out comparatively late the value of the decimal fraction, the pupil of the elementary school should not be required to wait until after he has studied all of common fractions before he is allowed the valuable aid of decimals in com-

putation. Again, while the race worked algebraic problems long before the fundamental operations of algebra were fully developed, pupils should not be expected to work more than a few very simple problems before they learn the language and the simple processes of algebra. It appears that some of our present texts are introducing too difficult problems for the introductory work in algebra. Again, while the notion of function was a late but most fundamental development in the history of algebra, the opportunity to grasp an elementary idea of function should not be lost in elementary algebra; such as is offered through the use of the graph. The writer does not believe, however, that the elementary course in algebra should be merely an introductory course to the theory of functions.

Besides knowing the history of mathematics in order to understand the tendencies and difficulties of the race in its mathematical development and to appreciate better possible similar traits in the pupil's mathematical development, the teacher should know the history of mathematics also for the sake of understanding the development of its subject matter. Such a study will often throw light on the logical structure of certain phases of this subject matter. For example, the teacher of geometry who knows of the study of parallels from the time of the early Greeks to the present, who knows of the necessity of Euclid's assumption, who knows of the later attempts to prove the parallel axiom, and who knows something of the development of non-Euclidean geometry, is in a position of authority when treating the subject of parallels. With this historical perspective the teacher will know why a student should not expect to prove the parallel axiom. Again, a teacher who has read the history of the three famous problems of antiquity is fortified against the importunities of the circle squarer, the angle trisecter, and the cube duplicater.

The high-school student is concerned only in an indirect way with the history of mathematics. The teacher may often stimulate a class in arithmetic, algebra, or geometry by relating an historic fact immediately related to the work in hand. Thus, in geometry by referring to the methods of the rope fasteners or to the probable origin of the recognition of the truth of the Pythagorean theorem; or in algebra, to a method used by the Hindus in solving quadratic equations; or in arithmetic, to some early number symbols or methods of multiplying or dividing. The practicing teacher is right in contending that there is no time for frills and fancies in teaching mathematics, where much drill is nec-

essary to bring about a fair degree of proficiency on the part of the pupils; but if the teacher keeps alive his own interest in the history of mathematics he can often find opportunity to give his class incentives to do harder and better work.

INDUSTRY IN THE LEADING COPPER PRODUCING STATES.

ARIZONA.

For 1910 Arizona again takes the lead among the copper producing states with an output slightly above the production of 1909, which was 291,110,298 pounds. The Bisbee district was the largest producer, with an output of approximately 145,000,000 pounds, as compared with about 130,000,000 pounds for 1909.

MONTANA.

The copper production of Montana will probably not exceed 285,000,000 pounds for 1910, as compared with 314,858,291 pounds for 1909. The state will therefore rank second to Arizona as a copper producer.

MICHIGAN.

Michigan, ranking third as a copper producing state, made an output of refined copper of about 220,000,000 pounds in 1910, as compared with 227,005,923 pounds for 1909.

UTAH.

Utah, ranking fourth among the copper producing states, made a marked increase in production over that for 1909, which was 101,241,114 pounds. The production was mainly from the Bingham district.

NEVADA.

The production of copper in Nevada for 1910 was about 64,000,000 pounds, as compared with 53,849,281 pounds for 1909. The output was mainly from the Ely district, the ores coming entirely from the Copper Flat pit.

CALIFORNIA.

The output of copper from California will show a considerable decrease in 1910 from the output of 53,568,708 pounds produced in 1909. The decrease is due to the necessity of controlling the smelter fumes in the Shasta County district.

TENNESSEE.

Tennessee will also show a decrease for 1910 from the output of 19,207,745 pounds for 1909. This decrease is due to the fact that the sulphuric acid plants operated by both companies in the Ducktown district were not able to handle the fumes produced by the smelting plants when they are operated at full capacity.

CHICAGO TEACHERS EXAMINATION.

The Board of Education of Chicago will hold an examination June 26 and 27, 1911, for teachers in high schools, the following majors only: Spanish, Polish, zoölogy, physiology and sanitation, physics, chemistry, mathematics, accounting, foundry, blacksmithing, electrical construction, mechanical drawing, physiography, phonography, commercial geography, and physical education. Write the Board's examiners for information.

PROVISIONAL REPORT OF THE NATIONAL COMMITTEE OF FIFTEEN ON GEOMETRY SYLLABUS.

(Continued from April issue.)

SECTION B. LOGICAL CONSIDERATIONS.

AXIOMS.

(a) **Nomenclature.** The best historical usage distinguishes between Axioms (Euclid's "Common Notions") and Postulates (Euclid's "aitemata" or "requests") by including in the former certain general statements assumed for all mathematics, and in the latter certain specifically geometric concessions. These names and this distinction are now in general use and there seems no good reason for attempting to change them. However, teachers who may wish to use the single term "assumptions" to cover both, or to use the term "axiom" to mean any proposition whose truth is postulated, should be free to do so.

(b) **General Nature.** It is evident that strict mathematical science would lead us to seek and to recommend an "irreducible minimum" of assumptions, while educational science leads us to see that such a list would be unintelligible to pupils and therefore unusable in the schools. Since we cannot recommend the adoption of a set of assumptions along the Hilbert line, we therefore lay down the general line of axioms and postulates needed in geometry, without insisting upon an exact list or upon any particular phraseology.

(c) **General List of Axioms.**

As to the nature of the quantities, positive quantities are to be understood. When the negative quantity enters into elementary geometry it is in the discussion of propositions and not in cases in which the axioms are directly employed. For example, it is desirable not to confuse beginners in geometry by the question of dividing unequals by negative numbers.

Operations upon equal quantities. It should be stated, preferably in a series of axioms, that if equals are operated upon by equals in the same way, the results are equal: i. e., if $a = b$ and $x = y$, then $a + x = b + y$, $a - x = b - y$ (where $a > x$), $ax = by$, etc.

Operations upon unequal quantities. It should be stated that if unequals are operated on by equals in the same way, the results are unequal in the same order; i. e., if $a > b$ and $x = y$, then $a + x > b + y$, etc. These various cases enter into ele-

mentary geometry, and this assumption should be stated in such a manner that the student can easily refer to it in his work.

There is also the assumption that if unequals are added to unequals in the same order the sums are unequal in the same order, and that if unequals are subtracted from equals the remainders are unequal in the reverse order, these being the only ones relating to two inequalities that are needed in elementary geometry.

As to substitutions. In geometry it is continually necessary to make use of the assumption that a quantity may be substituted for its equal in an equation or in an inequality. Often this assumes the common form that "quantities that are equal to the same quantity are equal to each other." The committee recommends this axiom, leaving it to the teacher as to whether it shall be given in one form for convenience of reference, or as two separate axioms.

Inequality among three quantities. It is necessary to say in geometry that if $a > b$ and $b > c$ then $a > c$, and an axiom to this effect is necessary.

The whole and its parts. Although the definition of "whole" might be given in such a manner as to render unnecessary the usual axiom, it seems advisable to make the statement in the ordinary form.

Summary. Axioms covering the above points are of advantage in the practical teaching of geometry, but this committee has no recommendation to make as to order or phraseology, nor does it insist that such a general form as $\sqrt[x]{a} = \sqrt[x]{b}$ be used, although already met in algebra, if the teacher prefers the special form $\sqrt{a} = \sqrt{b}$. They may be summarized as follows:

If $a = b$ and $x = y$, then

(1) $a + x = b + y$. (3) $ax = by$.

(2) $a - x = b - y$ $(a > x)$. (4) $a/x = b/y$.

(5) $a^x = b^x$ and $\sqrt[x]{a} = \sqrt[x]{b}$.

(6) If $a > b$ and $x = y$, then $a + x > b + y$, $ax > by$, $a/x > b/y$, and if $a > x$, then $a - x > b - y$.

(7) If $a > b$ and $c > d$, then $a + c > b + d$, and if $x = y$, then $x - a < y - b$.

(8) If $a = x$, and $b = x$, then $a = b$.

(9) If $x = a$, we may substitute a for x in an equation or in an inequality.

(10) If $a > b$ and if $b > c$, then $a > c$.

(11) The whole is greater than any of its parts, and is equal to the sum of all its parts.

(d) General List of Postulates.

(1) *One straight line and only one can be drawn through two given points.*

Corollary 1. *Two points determine a straight line.*

Corollary 2. *Two straight lines can intersect in only one point.*

(2) *A straight line-segment may be produced to any required length.*

This includes one postulate and one problem of Euclid, and so manifestly depends upon the simplest uses of straight edge and compasses as to be a proper geometric assumption.

(3) *A straight line is the shortest path between two points.*

(4) *A circle may be described with any given point as a center and any given line-segment as a radius.*

(5) *Any figure may be moved from one place to another, without altering its size or shape.*

(6) *All straight angles are equal.*

This and the following corollaries may be included among the theorems for informal proof under Section E.

Corollary 1. *All right angles are equal.*

Corollary 2. *From a point in a line only one perpendicular can be drawn to the line.*

Corollary 3. *Equal angles have equal complements, equal supplements, and equal conjugates.*

Corollary 4. *The greater of two angles has the less complement, the less supplement, and the less conjugate.*

The above axioms and postulates may be recommended for use as soon as the formal proof of propositions is begun, the necessary postulate of parallels being introduced when needed, as follows:

Postulate of Parallels. *Through a given point one line and only one can be drawn parallel to a given line.*

The question of limits is considered later. It is not deemed desirable to postulate explicitly the existence of such concepts as point, line, and angle, nor to assume that a line drawn through a point in a triangle must cut the perimeter twice, nor to add a postulate of continuity. It is well, however, for teachers to mention incidentally that such assumptions are always *tacitly* made. It is possible that some simple formulation of the pos-

tulate involved in the case of the triangle, just mentioned, may eventually find place in the regular list.

In any case the committee feels that a certain amount of care should be taken in fixing the location of points and lines and proving that lines intersect, when the accuracy of the proof in question might be affected by ignoring such details.

Definitions.

(a) **New Terms.**

(1) *General principle.* It is unwise for individual teachers or writers to introduce terms beyond those actually in common use in geometry, or to change the accepted meaning of common terms, unless there is a positive and general demand therefor, and an unquestionable sanction in the mathematical world. In particular, the substitution of a new term for an old one to denote the same concept, is undesirable.

(2) *Type of terms that may safely be added* to those of the older elementary geometry: *Congruent,* because this is so widely used both here and abroad, and because it avoids the loose use of *equal* and the long forms of *identically equal,* and *equal in all their parts.*

(3) *Types of terms that may safely be dropped*: *scholium,* because this has been so generally abandoned, and because it is unnecessary; *mixed line,* an antiquated term of no value in elementary geometry.

(4) *Type of terms that seem of too doubtful advantage* to be recommended definitely by this committee, teachers being left free to use them if they desire, the terms thus being given an opportunity to make their way if they possess real merit: *ray,* a term that has abundant sanction in higher geometry, but may be dispensed with in elementary work.

(5) *Types of terms that are used with a different meaning in higher geometry,* and that may properly be used in elementary geometry with the more recent signification: *circle* as meaning the line, which is, indeed, the primitive Greek meaning; *circumference,* as meaning the length of the circle—these usages requiring a redefining of *segment of circle, semicircle, area of circle,* and other obvious terms.

The committee recognizes also the tendency to unify the usage of such terms as *polygon* and *sphere* in elementary and higher geometry. This tendency should be encouraged. In any case, it is essential that the pupil should understand clearly what the

terms mean in the statements and proofs of the propositions as studied by him.

(**b**) **Symbols.**

(1) *General principle.* No symbols should be recommended beyond such as are already in wide use in elementary geometry, and any that are unnecessary or are not generally accepted should be abandoned. The elaboration of personal symbolism, sometimes to the point of eccentricity, is such as to be cumbersome in the mathematics of the present.

(2) *Recommendations.* The committee feels that the common symbols of algebra, most of which are known to the pupil beginning geometry, and such obvious symbols as those for perpendicular, triangle, circle, square, and parallel, are all that are needed in a course in elementary geometry, and that it is unnecessary to specify these symbols in detail. It appears that there is no generally received symbol for congruence, the symbols $=$, $\equiv$, and $\cong$ all being in use, and it seems best to recognize this fact, leaving teachers at present to decide the question for themselves. In due time a general consensus of opinion may lead to some definite usage, and it is the feeling of the committee that the second symbol given is a desirable one.

(**c**) **Distribution of definitions.** The committee recommends that new terms be taught when the time arrives for using them. This allows a teacher to use a book in which the definitions are massed or one in which they are scattered, but it encourages teaching them on the latter plan. It is recognized that the massed plan has the advantage of a dictionary arrangement, and this is a plan that a text-book writer might reasonably adopt, but it is not a plan to be followed in the actual teaching of the terms.

(**d**) **The definable and the undefined.** The attention of teachers is called to the fact, now coming to be well recognized, that certain terms in geometry are *undefinable* in a strict sense, or at any rate are better looked upon as *undefined.*

Certain concepts are so elementary that no simpler terms exist by which to define them, although they can easily be explained. For example, *point, line, surface, space, angle, straight line, curve.* The committee recommends that teachers give more attention to instilling a clear concept of such terms and none to exact definition.

On the other hand the committee recommends the careful definition of readily definable terms, where these definitions are

parts of subsequent proofs, such definitions to be memorized exactly or in their essentials. For example, *right angle, square, isosceles triangle, parallelogram.*

There is a further class of easily defined terms, where the definition is not made the basis of a proof, and it seems obvious to the committee that the memorizing of the exact wording of such definitions is not a wise expenditure of time. Such terms are *hexagon, heptagon, reëntrant angle, concave polygon,* etc.

(e) **The form of definition.** A definition may begin with the term defined, as in a dictionary; or it may close with the word defined; or it may at times contain the word in the midst of the sentence. The committee feels that it is of no moment which of these forms is taken, or that the definition be embodied in a single sentence. A definition that is to be memorized as the basis of a proof should be as nearly scientific as the powers of a beginner in geometry will justify, containing only terms that are simpler than the term defined, not being tautological, and being reversible—but further than this it seems unwise to attempt to specify the form of a definition.

Informal Proofs.

(a) **Justification.** It is not pretended that elementary geometry is a perfect piece of logic. In general, the modern departures from Euclid have sacrificed logic for other ends, and even Euclid's *Elements* was not without numerous logical imperfections. That is to say, it has always been considered justifiable to sacrifice logic to a greater or less degree. The principle is that a logical sequence should be maintained, and formal proofs of propositions necessary to the sequence should be required, so far as this is consonant with the educational principle of adapting the matter to the mind of the learner. Now in many cases it happens that an informal and confessedly incomplete proof is more convincing to a beginner than a formal and complete one, and is less discouraging because it postpones the minor and seemingly unimportant steps to a time when their importance may be appreciated and the proofs understood.

(b) **Types.** To be specific, the following are types of propositions that are better passed over by the beginner without formal statement, being introduced at the proper points in the development, or with informal proof, than proved in the euclidean fashion:

If one straight line meets another the sum of the two adjacent angles is a straight angle, and conversely (and related propositions);

All straight angles are equal (a proper postulate with related corollaries);

Two straight lines can intersect in only one point;

A straight line can have but one point of bisection (and the related case for angles);

The bisectors of vertical angles lie in one straight line;

Polygons similar to the same polygon are similar to each other;

If one angle is greater than another, its complement is less than the complement of the other (and related propositions);

A straight line can cut a circle (circumference) in two points only;

Circles of equal radii are equal (and related statements);

All radii of the same circle are equal (and similarly for diameters);

A circle can have but one center;

And propositions relating to the conditions under which two circles (circumferences) intersect.

It should be understood that these propositions are merely types, and that others of the same type may be treated in the same way, as specified in Section E of this report.

(c) **Experience of other countries.** It is the experience of all countries where Euclid is not taught that good results follow from the use of a reasonable number of such informal proofs. The German and Austrian text-books are especially given to such procedure, and the results seem to have been favorable rather than otherwise. The number of propositions formally proved in a German text-book is notably less, for example, than in a corresponding French text-book.

(d) **Dangers.** It is evident, however, that we may easily go to a dangerous and ridiculous extreme in this matter. With all of the experiments at improving Euclid the world has really accomplished very little except as to the phraseology of propositions and proofs; the standard propositions remain, and if geometry has any justification, apart from its kindergarten aspect (which requires but a short time), most of these propositions will continue to be proved, and should continue to be proved. These propositions, whether in the Euclid or Legendre arrangement, number in the neighborhood of 160 for plane

geometry. Of this number upwards of one hundred must receive formal proof in any well-regulated course in geometry.

TREATMENT OF LIMITS AND INCOMMENSURABLES.

(a) **Present status.** It is generally agreed that the present treatment of this subject is open to two objections, (1) it is not sufficiently understood by the student to make it worth the while, and (2) it is not scientifically sound.

(b) **Remedies proposed.** Corresponding to the two defects mentioned two remedies have been proposed, (1) to make it less formal and technical, so that it shall be better understood, and (2) to abandon the incommensurable case altogether in secondary education.

(c) **The position of this committee.** This committee recommends that in elementary geometry the nature of incommensurables and limits be explained, but that the subject no longer be required for entrance to college or be included in official examinations. It recommends that the schools treat the subject as fully beyond this point as circumstances seem to demand, and to this end reference is made to the syllabus given in Section E.

The prime object is to relieve the schools of the necessity of teaching the subject, while leaving them free to do so if they wish.

TIME AND PLACE IN THE CURRICULUM.

(a) **Conventionally.** At present, in America, plane geometry is generally taught in the tenth school year (not counting the kindergarten).

In the East it is completed in the eleventh school year, and in the West solid geometry is completed in the eleventh or twelfth year. In spite of all the discussion about constructive geometry (intuitive, metrical, etc.) in the first eight grades, carried on in the past half century, no generally accepted plan has been developed to replace the old custom of teaching the most necessary facts of mensuration in connection with arithmetic. We have, therefore, at this time, algebra in the ninth school year, plane geometry in the tenth, and algebra and geometry in the eleventh and sometimes in the twelfth.

(b) **Changes suggested.** Certain changes in this conventional plan have been suggested.

(1) To provide for preliminary (inductive, constructive, observational) work in geometry in the elementary grades. This topic is discussed in Section C of this report.

(2) To precede the work in plane geometry by some definite work in geometric drawing. Attention may be called to the fact that the recent great advance in art education has had one disadvantage from the standpoint of geometry, in that geometric drawing has been abandoned, and that therefore some little work in handling compasses and ruler must now form part of the first steps in this subject.

(3) To unite geometry and algebra, or geometry and trigonometry. This committee does not feel that the experiments along this line have been sufficient to determine whether or not geometry should run parallel with algebra in the ninth, tenth and eleventh school years.

(c) Position of this committee. This committee recommends that plane geometry be assigned not less than one year nor more than one and one half years in the curriculum, being preceded by at least one year of algebra except where the individual teacher desires to carry it along with algebra.

It should be distinctly understood that owing to the condition of unrest in the entire field of secondary education it is at present impossible to give any final advice along any of these lines of change. It is probable that many of the readjustments now under general discussion will influence every high school curriculum in the course of time. It is also possible that some of the proposed changes will be adapted by the different types of secondary schools to their own needs, and that they will receive greatly varying emphasis in different localities. A certain amount of experimentation will undoubtedly be necessary to test the feasibility of some of the proposed plans. Great care should be taken to make all such experimentation with due regard for all that was good in the past, so that the new curricula may be the result of evolution, and not of revolution.

The most noteworthy tendency in secondary education is the desire for more organic teaching and hence the desire for more time. This tendency finds its most significant expression in the movement toward a *six-year curriculum.* It is undoubtedly true that in a six-year curriculum many of the problems of correlation would be brought nearer to a solution, that many difficulties arising from the present tandem system would disappear, and that mathematics would be given a place in the curriculum more nearly commensurate with its importance.

For a brief account of the six-year curriculum the reader is referred to the book of Hanus entitled *A Modern School,* pub-

lished by the Macmillan Company; and also to the Proceedings of the National Education Association for 1908.

PURPOSE IN THE STUDY OF GEOMETRY.

(a) **Historical review.** Geometry was originally, as its name indicates, purely a practical subject. This phase of its history remains in the work in mensuration in arithmetic to-day. It then became a philosophical subject, connecting with mysticism in the Pythagorean school, being put upon a more solid scientific basis by the Platonists, and being crystallized by Euclid about 300 B. C. Since that time the formal side has dominated. But this formal side has been attacked time after time, by the astrologers and mystics, by the cathedral builders of the Middle Ages, strongly by the French writers of the seventeenth and eighteenth centuries, recently by an extreme school in England, and at present in a less formidable fashion in our own country. The results of these attacks in so far as they have meant the abandoning of formal proofs have been futile.

(b) The practical side. In the high school geometry has long been taught because of its mind-training value only. This exclusive attention to the disciplinary side may be fascinating to mature minds, but in the case of young pupils it may lead to a dull formalism which is unfortunate. On the other hand those who are advocating only a nominal amount of formal proof, devoting their time chiefly to industrial applications, are even more at fault. The committee feels that a judicious fusion of theoretical and applied work, a fusion dictated by common sense and free from radicalism in either direction, is necessary.

As to the nature of the applications, the committee feels that there are several types of genuine problems, but that many of the so-called real applications either are too technical to be within the grasp of the young beginner, or represent methods of procedure that would not be followed in real life. Moreover, it should be remembered that the very limited time devoted to plane geometry (usually a single year) renders it impracticable to introduce many of the applications that might be desirable if the time were not so restricted.

(c) **The formal side.** No reference to the applications of geometry is to be construed to mean that the committee feels that the formal side should suffer, or that geometry is wanting in a distinct disciplinary value. A formal treatment of geometry, to about the traditional extent, is necessary purely as a prerequi-

site to the study of more advanced mathematics, and still more because such treatment has a genuine culture value.

Certain writers on education have claimed that geometry has no distinctive disciplinary value, or that the formal side is so intangible that algebra and geometry should be fused into a single subject (not merely taught parallel to each other), which subject should occupy a single year and be purely utilitarian. These writers utterly fail to recognize the fundamental significance of mathematics in either its intellectual or its material bearing.

(**d**) **Claims for geometry.** Among the claims in behalf of geometry the committee would emphasize the following:

Geometry is taught because of the *pleasure* it gives when properly presented to the average mind.

Geometry is taught because of the *profit* it gives when properly presented. For example:

(1) It is an exercise in logic, and in types of logic not generally met in other subjects of the school course, and yet types which occur in geometry in unusually simple setting and which are easily carried over into the actual affairs of life. Closely connected with the logical element is the training in accurate and precise thought and expression and the mental experience and contact with exact truth.

This logic may be no more practical than literature or art or any other great branch of learning, but its general effect on the human mind has been doubted by such a small number of scholars as to render it worthy of the highest confidence.

(2) The study of geometry leads also to an appreciation of the dependence of one geometric magnitude upon another, in other words to the tangible concept of *functionality*.

(3) The study of geometry cultivates space intuition and an appreciation of and control over forms existing in the material world, which can be secured from no other topic in the high school curriculum.

(4) The value of the applications of geometry to mensuration and the satisfaction derived by the pupil in verifying the formulas of mensuration already met by him in arithmetic are well recognized by all teachers.

If we had to justify the position of any other subject in the curriculum, history, rhetoric, geography, biology, etc., it is doubtful whether equally specific and cogent reasons could be found. If we were to dismiss geometry with a few practical lessons,

much more should we be compelled to dismiss most other subjects in the curriculum with the same treatment.

Historical Notes.

Of the stimulating effect of occasional bits of historical information given by the teacher or the text-book there can be no question. There is plenty of material to be found in the well-known elementary histories of the subject. The discoverers of particular propositions are known in a few cases, and the general story of the subject, told informally as the pupil proceeds in his study, adds a human interest that is valuable. Portraits of famous mathematicians may be recommended for the schoolroom.

Points Relating to Solid Geometry.

(a) **Axioms and Postulates.** The list of axioms already given need not be increased, but the following postulates may be added:

(1) *One plane and only one can be passed through two intersecting straight lines.*

Corollary. *A plane is determined by three points not in the same straight line, by a straight line and a point not in it, or by two parallel lines.*

This postulate, which is the analogue of the first postulate in plane geometry, may also be given as a theorem for informal proof.

(2) *Two intersecting planes have at least two points in common.*

(3) *A sphere may be described with any given point as center and any given line-segment as radius.*

It is tacitly assumed that the figures described in the course in solid geometry exist and can be made the subject of investigation; e. g., the prism, pyramid, cylinder, cone, etc.

It may also be assumed, tacitly or explicitly, that the various closed solids have definite areas and volumes; e. g., that a sphere has a definite volume which is less than that of any circumscribed convex polyhedron and greater than that of any inscribed convex polyhedron.

(b) **Definitions.** Latitude is left to the teacher in regard to the use of such terms as prismatic space, cylindrical space, nappes of a cone, and some of the names suggested for a rectangular parallelepiped, which are convenient but not necessary in an elementary course.

After the analogy of the circle defined as a line, it is proper that the sphere be defined as a surface but the more common definition may be retained if desired.

(c) Purpose. In solid geometry the utilitarian features play an increasingly important part. The mensuration involved in plane geometry is so simple as to be fairly well understood as presented in arithmetic. Solid geometry, however, offers a rather extended field for practical mensuration in connection with algebraic formulas. The subject is therefore particularly valuable for high school classes. A further application is found in the power afforded to visualize solid forms from flat drawings, a power that is essential to the artisan and valuable to everyone. The committee therefore summarizes the purposes of solid geometry as follows:

(1) To emphasize and continue the values of plane geometry, mentioned above;

(2) To present a reasonable range of applications to the field of mensuration;

(3) To cultivate the power of visualizing solid forms from flat drawings, without entering the technical domain of descriptive geometry.

SECTION C. SPECIAL COURSES.

(a) Courses for Different Classes of Students.

One of the topics which this committee undertook to consider was that of different courses for various classes of students in the high schools.

After investigation, it is the belief of the committee that there should be no attempt to outline such courses. The syllabus as recommended in Section E may be altered in special cases by the omission of the theorems printed in small type and by increased emphasis upon theorems which admit of direct practical applications.

The preceding recommendation, together with the possible omission of solid geometry, would reduce the course to less than half the traditional length. It seems probable that no greater reduction would be desirable even for students in purely commercial courses, or indeed in any course in which formal geometry is a required subject.

(b) Preliminary Courses for Graded Schools.

A portion of the report of this committee was to deal with preliminary courses to be undertaken in graded schools.

Recommendations. It is of the utmost importance that some work in geometry be done in the graded schools. For this there are at least two very strong reasons. In the first place, geometric forms certainly enter into the life of every child in the grades. The subject matter of geometry is therefore particularly suitable for instruction in such schools.

Moreover, the motive for such teaching is direct. The ability to control geometrical forms is unquestionably a real need in the life of every individual even as early as the graded school. For those who cannot proceed further this need is pressing; the direct motive involved compares very favorably with any other direct motive for work in the grades. For those who are going on to the high school, the development of the appreciation of geometric forms is almost an absolute prerequisite for any future work in geometry.

Informal work. It is quite obvious that no work of formal, logical character should be undertaken in the graded schools. The earliest work in geometry will doubtless be so informal that it will not constitute a separate course. Instruction in drawing, in pattern making, and in elementary manual training furnishes a basis for considerable geometric work even in the first grades of the primary school.

Such work as this should be encouraged, though no special outline of it can be given on account of its dependence upon other courses. The constructions for erecting perpendiculars, bisectors of angles, etc., can and should be given in connection with such manual training work as making boxes, patterns, etc., though no technical nomenclature need be used. In such work paper folding and the use of simple instruments should be encouraged, including the compasses, the ruler, and in later years the protractor and squared paper.

Mensuration. In connection with arithmetic much geometric work may be taken up which is consistent with the child's real interests and life. Measurement may be introduced very early and the mensuration of simple forms such as the square, rectangle, and triangle need not be long delayed. After this, other geometrical forms and solids may be introduced under the head of mensuration even earlier than is now customary. In properly conducted schools, the students will become familiar at the same time with such figures as the circle, cube, sphere, etc., in manual training and in other elementary courses, such as nature study, geography, etc.

In the later grades practically all of the simple geometric forms will find their place in arithmetic under the head of mensuration, in drawing, and in manual training.

Work in the higher grades. A special course in geometry in the graded school is desirable, if at all, only in the last grade or the last two grades. In such a course no work of demonstrative character should be undertaken, though work may be done to *convince* the student of the truth of certain facts; for example, by paper folding or cutting a variety of propositions may be made evident, such as the sum of the angles of a triangle is 180°, etc. The theorem just named is typical of the theorems which the student should know as *facts* before he leaves the graded school. Many others of the theorems printed in black faced type in the syllabus submitted herewith may be taught in this course without formal proof.

Theorems as facts. Emphasis should be laid upon the facts with which the student is already familiar through the work described above. The course should be regarded partially as a classification and a systematization of the knowledge previously acquired. Thus, simple geometrical forms should be brought up in the connection in which they have arisen in the student's past experience. In taking up constructions, explicit mention should be made of the previous work in which a given construction occurred, and further practical instances of the use of such constructions should be given.

Drawing to scale. Emphasis should also be laid on other work of a concrete nature which involves direct use of geometric facts. Thus the propositions concerning the similarity of triangles should be introduced by means of the drawing of figures to scale. Attention should be called to the cases in which figures have been drawn to scale in the past. The usefulness and the necessity of the operation should be emphasized, and such applications as the drawing of house plans, the copying of patterns on a smaller scale, etc., should be given. The use of cross section paper for this purpose may be encouraged. Finally after the notions involved are very clear indeed, and after actual measurements have been made and reduced to scale the precise facts regarding similar triangles may be given. This should follow and not precede the work described above. The applications to elementary surveying should, if possible, be made in actual field work.

Models and patterns. The situation just described for sim-

ilar triangles should be carried out so far as possible in other instances. Thus the important theorems on the measurement of angles can be illustrated in many ways. The Pythagorean theorem, without formal proof, can be illustrated and made real to every student by reference to the pattern forms in which it occurs, the calculation of distances, and other real applications. Finally the mensuration formulas can all be given. In the latter, concrete illustrations should abound and verification by means of models and measurements upon them should be encouraged.

Forms of solid geometry. Contrary to the traditional procedure, the forms of solid geometry should be emphasized even more than those of plane geometry, for they are more real and more capable of concrete illustration.

Not only should formal demonstration be avoided but also long lists of definitions which tend to confuse rather than enlighten. Definitions should be stated formally only *after* the concept is clearly formed in the student's mind. No axiom should be stated as such at any point, though frequent assumptions should be made without an attempt at proof. In all such cases care should be taken that the statements made seem reasonable to the student and no forward step should be taken until he is absolutely convinced of the truth of the statement.

Justification. That such work is of vital value to the student can scarcely be doubted; that it is absolutely legitimate will probably be admitted by all interested in primary education. Its value, its real direct motives, its contact with life, the legitimacy of its subject matter exceed incomparably those of the traditional course in advanced arithmetic. At least, the course in arithmetic may be vitalized by a liberal infusion of such geometric work.

If such a course is not given in the grades—perhaps even though it is—a course of similar character but very much shorter may be given in the high school before formal work in demonstrative geometry is attempted. In any event it is desirable that the course in formal geometry should not proceed in its traditional groove until the teacher is assured that the ideas mentioned above are thoroughly familiar to the student.

SECTION D. EXERCISES AND PROBLEMS.

Distribution, Grading, and Nature of Exercises.

(a) Increasing number of exercises. There has been a growing tendency in the last two decades to increase *abnormally* the num-

ber of exercises to be considered by each pupil under the following heads: (1) long lists of additional theorems (beyond the full set usually given in the texts), (2) long lists of problems of construction having at best remote connection with any uses of geometry within reach of the ordinary high school pupil, (3) long lists of numerical exercises given in the abstract, that is, unrelated to any concrete situation familiar to the pupil or arousing his interest.

To give a single illustration of each:

(1) The squares of two chords drawn from the same point in a circle have the same ratio as the projections of the chords on the diameter drawn from the same point.

(2) To construct a triangle having given the perimeter, one angle and the altitude from the vertex of the given angle.

(3) Through a point P in the side AB of a triangle ABC, a line is drawn parallel to BC so as to divide the triangle into two equivalent parts. Find the value of AP in terms of AB.

(b) The distribution of exercises. It is recommended that there should be treated in connection with each theorem such immediate concrete questions and applications as are available, and especially early in the course should such theorems be given as easily lend themselves to this class of exercises.

For example, in a treatment in which the theorems on congruence of triangles are placed early, there is the opportunity to bring in at once the simplest schemes for indirect measurement of heights and distances. Then later as similarity of triangles is taken up, there is the chance to recur to the same problems and let the pupil see how the principle adds power and facility in making indirect measurements. There is thus a progressive development in the facility for solving concrete problems along with the theory.

This principle can be carried out in many different lines. For example, in connection with triangles, circles, and squares, there are many applications immediately available and easily found in tile patterns, window tracery, grill work, steel ceiling patterns, etc. These afford fine exercises in construction early in the course, and are equally available later in the computation and comparison of areas. When such exercises are given they should be distributed as far as possible in connection with the theorems used in the construction and comparison of the figures involved.

However, only the simplest uses of the theorems can be shown in the immediate connection, both because of the space occupied by them and the danger of interrupting the continuity of the

theorems by too many exercises thrown in between them, and also because most of these applications make use of various different theorems, and hence must come after certain groups of theorems, thus making necessary occasional lists of problems and applications scattered through the various books, as well as sets of review exercises at the end of each book.

The whole question of distribution is thus to be determined by the relation of the problems and applications to the single theorems or groups of theorems to which they belong. The important question of emphasis in Section E of this report is best brought out by the grouping of many exercises around the basal theorems.

On the basis of distribution we have all extremes in the various texts, including: (1) The purely logical presentation, that is, the continuous chain of theorems with practically no applications in concrete setting in connection with them and almost none at the end of the books; (2) the same as the foregoing, except that the long sets of exercises are placed at the end of each book, where they loom up before the pupil as great tasks to be ground through, if, indeed, they are not omitted altogether; (3) the psychological presentation in which the more difficult exercises are either postponed to a later part of the course or are omitted altogether, and the easier ones are brought into more immediate connection with the theorems to which they are related.

The time and space made available by the third method of presentation provides an opportunity for the pupil to gain some acquaintance with the uses of the theorems as he proceeds and to become genuinely interested in the development of the subject. The committee strongly recommends this latter method of presentation. In expressing its disapproval of method (2), it is not to be understood that the committee objects to any text-book because it offers a large number of exercises, placed at the end of each book, from which the teacher is to make a selection. The objection to (2) should be clear from reading (3). which the committee approves.

(c) **The grading of exercises.** Too much cannot be said in favor of a large number of simple cases rather than too many difficult questions, especially early in the course, but also even throughout the secondary course in geometry.

The average high school pupil is not likely to become adept at proving difficult and abstruse theorems independently or in solv-

ing complicated problems. On the other hand, the rank and file are bound to become discouraged and hopelessly lost in the so-called "originals," unless the grading is carefully done, and steps of difficulty are kept down to a very reasonable lower limit.

The ideal treatment would seem to be: (1) To make a proposition appeal to the pupil as reasonable by simple illustrations, after which should follow the deductive proof; (2) to apply the theorem to more difficult situations, involving problems which the pupil regards as interesting and worth while. It is recognized that this ideal cannot be attained with reference to all the theorems of geometry but it is believed that it can be attained in very many cases; and, wherever this is possible, very great interest and incentive is given to the pupil.

As a matter of fact, familiarity with the elementary truths pertaining to angles, parallelograms, and circles, when consistently tried out and seasoned by applications to numerous comparatively simple and interesting geometric forms suggested by figures which abound in concrete setting on every hand within reach of all, is usually of more value to the average pupil (and even to the better pupils) than is the study of a larger number of abstract theorems or problems through which they are often forced. Nevertheless, for the benefit of the brighter pupils, it is desirable that a few comparatively difficult problems be given, especially at the ends of the various books, or in a supplementary list.

(d) **The nature of exercises.** This topic has been referred to under (a), (b), and (c). It is recognized that a fair proportion of the traditional exercises given in abstract setting should find a place in a course in geometry, but the committee believes that, in accordance with the common practice of the past twenty years this class of exercises has been magnified and extended, especially with reference to the more difficult exercises, beyond the interest and appreciation of the average pupil.

The committee therefore recommends that a judicious selection of a reasonable number of abstract originals be made in order to leave time for an equally reasonable number of problems, particularly those with local coloring, stated in concrete setting.

Since ample lists of abstract originals are within easy reach of all teachers of geometry, it seems unnecessary to supply illustrations of such exercises. But as the teacher must generally depend upon his own initiative to supply problems in concrete

setting, it seems desirable to indicate a few sources from which such problems may be obtained. The committee believes that a reasonable number of problems of this character creates an interest in the minds of the pupils that reacts strongly in augmenting his understanding and appreciation of the logical side of the subject. But it is not to be understood that the committee regards these problems as practical in the narrow sense of the word.

Sources of Problems.

(a) Architecture, decoration, and design. Industrial design and architectural ornament are replete with details that may be used as a source of supply for geometry problems. These problems are of three kinds: (1) The problems involved in the construction of the figures themselves; (2) The demonstrations necessary to establish numerous relations which are visible to the mathematician and which must occasionally be assumed by designers; (3) Problems in computation.

Among the industrial products that involve geometric ornament are tile and mosaic floors, parquetry, linoleum, oilcloth, steel ceilings, ornamental iron, leaded glass, cut glass, and the like. Figures for problems from these sources may be made from the cuts in trade catalogues.

Probiems based on architectural ornament are largely from details of Gothic tracery and can be obtained only by a study of the buildings themselves or of the photographs of them that may be seen in architectural libraries. Gothic tracery is found in windows, in ornamental iron, in carved stone and wood on the outside and inside of buildings, on furniture, choir screens, rafters, and the like, that abound in medieval cathedrals and churches and in their modern imitations.

These problems have distinct advantages. In many cases their comprehension and solution require no technical knowledge beyond the elementary mathematics needed. These designs abound, are largely within the reach of pupils, and their use in the class room brings before pupils as nothing else can the beauty and widespread application of geometric forms. In them may be found applications of many topics of elementary mathematics and from them may be obtained numerous exercises of all grades, from the simplest to the most complex. By their use it is possible, therefore, to introduce anywhere in the work problems that are within the reach of the average pupil and ap-

peal to him with a minimum of experiment, explanation, discussion, or previous special preparation.

(b) **Problems of indirect measurement.** It should not be considered that the types of applications under (a) are relatively of greater importance than numerous others. Any application that adds interest to the study of rigorous geometry is of value. Of special interest are all simple means of effecting indirect measurements of distances, such, for instance, as the numerous applications of the congruence theorems and the theorems on similarity of triangles. Here the teacher will find much assistance in Principal Stark's *Measuring Instruments of Long Ago.*[44] Again in considering the isosceles triangle, the universal leveling instrument (aside from the spirit level) offers a number of applications. The form is that of an isosceles triangle bisected by a line from the vertex.

Many simple and interesting problems in indirect measurement are made available by the introduction of the trigonometric ratios, *sine, cosine, and tangent.* This can be done as soon as the theorems on similar triangles are known, and the computation by measurement of a two place table of natural functions at intervals of $5°$ affords, of itself, a fine drill in the application of these theorems, at the same time providing material for solving concrete problems of great interest to young pupils.

It may not be possible to find time for this in connection with the usual course in plane geometry. Schools that devote most of their time and effort to preparing pupils to pass entrance examinations for college would certainly find it difficult to meet any added requirement. In view, however, of the omissions suggested by this committee and the readjustment of emphasis on basal theorems, time may be found, as the experience of an increasing number of teachers has shown. Where this can be done it constitutes an important step in the closer correlation of the subjects in elementary mathematics. In any case only the natural functions should be used, and the applications should be limited to those involving right triangles.

(c) Other sources. Problems may also be obtained from physics, mechanics, and other sciences, from engineers' and builders' manuals and works on carpentry and masonry, as, for instance, problems derived from various common forms of trusses and the construction of arches. But there is a danger in connection with problems from these sources, that aside from the geometry in-

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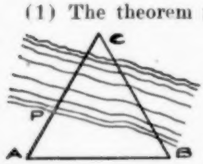
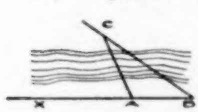
[44]School Science and Mathematics, Vol. X, pp. 48, 126.

volved, they may contain technical terms and mechanical features unknown to the average pupil and not easily understood without more explanation and consequent distraction from the geometry itself than is warranted in the ordinary course. Problems of this class should be carefully tried out and sifted before being adopted for use.

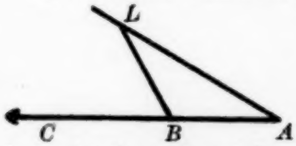
(d) **Illustrative problems.** There are given below a few typical problems which are suggested for the purpose of making clear what the committee has in mind. Through simple problems of these types and many others which might be suggested much interest can be imparted to the study of demonstrative geometry, even though the problems be not practical in the strict sense of the word. The danger of using too many problems in any narrow field is, however, apparent.



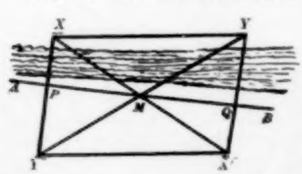
(1) The theorem regarding the angle sum in a triangle has a large number of applications. For example, to measure PC, stand at some convenient point A and sight along APC and (by the help of an equilateral triangle cut from pasteboard) along AB. Then walk along AB until a point B is reached from which BC makes with BA an angle of the equilateral triangle (60°). Then AC = AB, and since AP can be measured we can find PC. This is an example of a problem that adds interest to the work without being itself a practical application that would be used by a surveyor.



(2) A problem of the same nature is the following: To measure AC, first measure the angle CAX, either in degrees with a protractor or by sighting across a piece of paper and marking it down. Then walk along XA produced until a point B is reached, from which BC makes with BA an angle equal to half of angle CAX. Then it is easily shown that AB = AC.



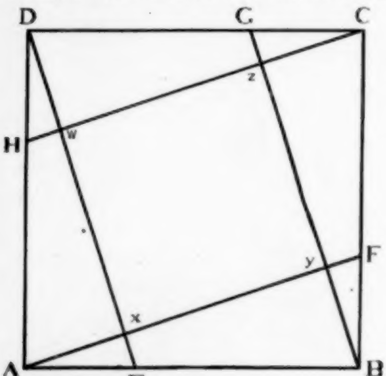
(3) The sailor makes use of this principle when he "doubles the angle on the bow" to find his distance from a lighthouse or promontory. If he is sailing on the course ABC and he notes a lighthouse L when he is at A, and takes the angle A, and if he notices when the angle that the lighthouse makes with his course is just twice the angle noted at A, then BL =AB. He has AB from his log, so he knows the distance BL.

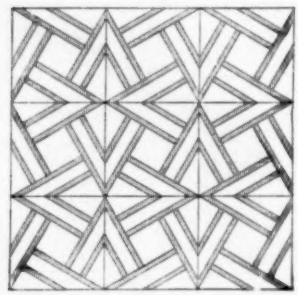


(4) To measure the line XY, when the observer is at A, we may measure any line AB along the stream. Then the observer may take a carpenter's square, or even a large book, and walk along AB until a point P is reached from which X and B can be seen along two sides of the square. Similarly the point Q may be fixed. Then by walking along YM to a point Y′ that is exactly in line with M and Y and also with P and X, the point Y′ is fixed. Similarly X′ is fixed. Then X′Y′= XY.

(5) A field containing 9 acres is represented by a triangular plan whose sides are 12 in., 17 in., and 25 in. On what scale is the plan drawn? Conant.

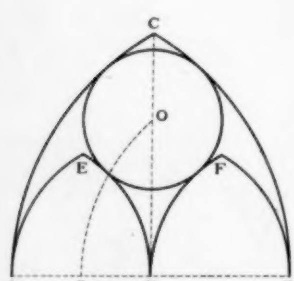
(6) Assuming the earth to be a sphere of which the radius is 3960 miles, find the length of one degree of longitude at 60° north latitude, and compare its length with that of one degree of longitude at the equator.

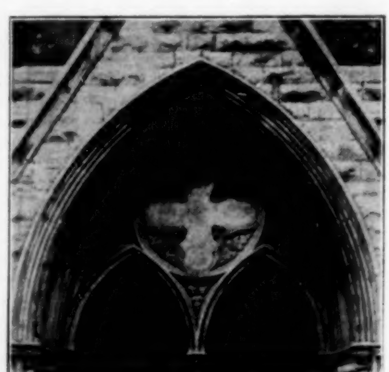




(7) ABCD is a square. Equal distances AE, BF, CG and DH are measured off on the sides AB, BC, CD and DA respectively. If the lines AF, BG, CH and DE are drawn intersecting at Y, Z, W and X, prove that XYZW is a square. If AB $= a$ and AE is $\frac{1}{3}$ of AB, prove that AF $= a/3\sqrt{10}$, AX$=a/10\sqrt{10}$, XY$=a/5\sqrt{10}$, FY$=a/30\sqrt{10}$; and that the area of XYZW is $2a^2/5$.

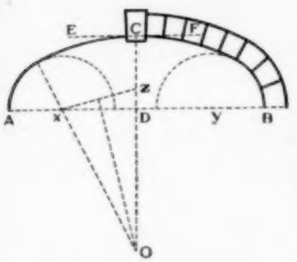
This figure is the basis of an Arabic design used for parquet floors. The solution involves both algebraic and geometric work in concrete setting.





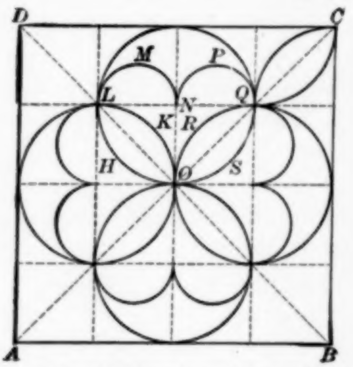
(8) ABC is an equilateral arch, and CD its altitude. A is the center of the arc BC and B the center of the arc AC. The equilateral arches AED and DFB are erected on AD and BD respectively. D is the center of arc AE and FB and A and B are centers of arcs ED and DF, each drawn with $\frac{1}{2}$AB as radius. What is the locus of centers of circles tangent to CA and CB? To ED and DF? To AC and DF? To CB and ED? Construct a circle tangent to the arcs AC, CB, ED and FD.

This figure is the basis of a common Gothic window design. The solution involves the intersection of loci.

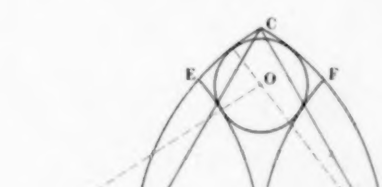


(9) CD is the perpendicular bisector of AB. Equal distances AX and BY are measured off on AD and BD respectively. EF is perpendicular to CD at C. Circles are drawn with X and Y as centers and AX and BY as radii. Construct a circle tangent to EF at C and to circle X. Prove that this circle is also tangent to the circle Y.

If CD is less than $\frac{1}{2}$AB the part of this figure between lines CD and AB is one form of a three centered arch.



(10) In the drawing above, which is the basis of the mosaic floor design to the right, the circle with center N is inscribed in one of the squares whose side is SH. The arcs ORQ and OKL are drawn with the vertices of the square as centers and half the side as radius. The semicircles LMN and NPQ are drawn on LN and NQ as diameters. Find the areas of the various figures bounded by circular arcs within this square. Note the symmetry of the whole figure within the square ABCD.



(11) ABC is an equilateral triangle. A and B are the centers of arcs BC and AC respectively. CD is the altitude of triangle ABC. Arcs DF and DE, constructed with radii equal to AB, are tangent to CD at D and intersect AC and CB respectively at E and F. Construct a circle tangent to the arcs DE, DF, AC and BC.

Suppose the problem solved. Let O be the center of the circle. Connect O with B, the center of arc AC, and with H, the center of arc DE. From

triangles ODB and OHD the following equation is derived:

$$(s - r)^2 - (s/2)^2 = (s + r)^2 - s^2,$$

where s is the length of AB and r is radius of the required circle.

This figure is the basis of a church window design. Many problems of this type may be easily obtained.

(12) A quarter mile running track has two parallel sides and semicircular ends. Each straight away section is equal in length to one of the ends. If the track measures exactly one-fourth of a mile at the curb, or inner edge, how much distance does a runner lose in running two feet from the curb? Six feet? What is the area of the track if it is 15 feet wide? What is the area of the enclosed field? What are the dimensions of a rectangular field sufficiently large to contain such a track? What will it cost at $2.00 per cubic yard to cover such a track with cinders to a depth of 2 inches? Pettee.

(e) References to sources of problems. In connection with the recent search for real applied problems in elementary mathematics numerous bibliographies have been compiled to which reference is here made, as well as to a few other books, aside from current texts, which may be helpful to teachers. Concrete problems should be selected carefully and used wisely. Those which may appear to one class of pupils as real applied problems may seem highly abstract to another class. Probably few problems in the following lists would appear real to all pupils and yet all are likely to find increased interest in any problem which has a concrete origin.

Printed bibliographies.

(1) A list of 38 titles of books and 21 titles of trade journals, *School Science and Mathematics,* Vol. IX, No. 8, 1909, pages 788-798.

(2) A more extended list of books on the whole range of applied problems, *School Science and Mathematics,* Vol. VIII, No. 8, November, 1908, pages 641-644.

From this list Saxelby, Godfrey and Siddons, and Perry may be mentioned especially.

(3) A comprehensive list of books and journals relating to the uses of geometry in architecture, decoration, and design in a forthcoming volume entitled *A Source Book of Problems for Geometry,* by Mabel Sykes. Allyn and Bacon, Boston, 1911.

(4) A vast bibliography of suggestive titles, with a classification and discussion of some phases of industrial problems by a committee of the National Education Association on *The Place of Industries in Public Education.* Proceedings of the Association, 1910, pages 652-788.

Collections of problems.

(1) Real Problems in Geometry, *Teachers College Record,*

March, 1909. A classification and discussion of types of applied problems, by James F. Millis.

(2) Real Applied Problems in Algebra and Geometry, *School Science and Mathematics.* A collection begun in 1909 by a committee of the Central Association of Science and Mathematics Teachers. The work is still in progress. The problems collected up to November, 1909, have been classified and published in pamphlet form.

Other selected titles.

(1) *Lessons in Experimental Geometry,* Hall and Stevens. The Macmillan Company, New York, 1905.

(2) *Numerical Problems in Geometry,* J. G. Estill. Longmans, Green and Company, New York, 1908.

(3) *Mensuration,* G. B. Halsted. Ginn and Company, Boston, 1903.

(4) *Elementary Mensuration,* F. H. Stevens. The Macmillan Company, New York, 1908.

(5) *A Notebook of Experimental Mathematics,* Godfrey and Bell. London, Edward Arnold, 1905.

(6) *Elements of Mechanics,* M. Merriman. John Wiley and Sons, New York, 1905.

(7) *Shop Problems in Mathematics.* Breckenridge, Mersereau and Moore. Ginn and Company, New York, 1910.

(8) *Pocket Companion containing Tables,* etc. Carnegie Steel Company, Pittsburg, Pa., 1903.

(9) *Leitfaden der Geometrie,* Jahne and Barbisch. Vienna, 1907.

(10) *Raumlehre für Mittelschulen,* Martin and Schmidt. Berlin, 1898.

(11) *Geometrie für die Zwecke des practischen Lebens,* G. Ehrig. Leipzig, 1906.

(12) *Mathematische Aufgaben,* Schulze and Pahl. Leipzig, 1908.

(13) *Cours abrégeé de Géométrie,* Bourlet and Baudoin. Paris 1907.

(14) *Cahiers d' exécution de dessins géometriques,* M. P. Baudoin. Paris.

(15) *Geometria Intuitiva,* P. Pasquali, Milan.

(16) *Regole di Geometria Pratica,* F. Aandreotti. Florence, 1897.

(17) *The Power of Form Applied to Geometrical Tracery,* R. W. Billings. London, 1851.

(18) *Gothic Architecture in England,* Francis Bond. London, B. T. Botsford, 1905.

(19) *Les elements de l'art Arabe,* Jules Bourgoin. Paris, 1879.

(20) *Pattern Design,* Lewis F. Day. London, B. T. Botsford; New York, Scribner's Sons, 1903.

(21) *Geometrische Ornamentik,* L. Diefenbach. Berlin, Max Spielmeyer.

(22) *Romano-British Mosaic Pavements,* Thomas Morgan. London, 1886.

(23) *Decorated Windows, A Series of Illustrations,* Edmund Sharpe. London, 1849.

(24) *Specimens of Tile Pavements,* Henry Shaw. London, 1858.

(25) *Specimens of Geometrical Mosaics of the Middle Ages,* Sir Matthew Wyatt. London, 1848.

(26) *The Teaching of Geometry,* David Eugene Smith. Boston, Ginn & Co., 1911.

(To be concluded in June.)

PROBLEM DEPARTMENT.

By E. L. Brown,
Principal North Side High School, Denver, Colo.

Readers of this magazine are invited to send solutions of the problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to E. L. Brown, 3435 Alcott St., Denver, Colo.

Algebra.

239. *Proposed by E. R. Gross, Long Pine. Neb.*

Solve: $x+2y+3z+4w=30$ (1).

$2x+3y+4z+5w=40$ (2).

$3x+4y+5z+6w=50$ (3).

$4x+5y+6z+7w=60$ (4).

I. *Solution by N. Anning, Chilliwack, B. C.*

Subtracting (1) from (2), (2) from (3), or (3) from (4),

$$x+y+z+w=10. \quad (5).$$

Subtracting (1) from four times (5),

$$3x+2y+z=10. \quad (6).$$

The given set reduces to these two equations in four unknowns. Consequently, our results must contain two arbitrary parameters. Represent them by m and n and let—

$x=a+bm+cn,$

$y=d+em+fn,$

$z=g+hm+kn,$

$w=10-(x+y+z),$

where a, b, ...k denote numbers to be chosen so that relation (6) is satisfied. This can be done in many ways. A simple form of the result is—

$x=1+m,$

$y=2-2m+n,$

$z=3+m-2n,$

$w=4+n.$

II. *Solution by Olaf K. Lie, Richmond, Mass.*

Multiply (1) by 2 and subtracting (2) we have—

$$y+2z+3w=20.$$

The same result is obtained by eliminating x between *any* two of the given equations, and this equation will give a doubly infinite number of solutions. But if zero and negative values are excluded and only integral positive value considered, we have a limited number of solutions. For in this case the value of w cannot exceed 5.

If $w=5$, then $y=1$, $z=2$, or $y=3$, $z=1$.

Substituting these two sets of values in (1), $x=2$ or 1.

These two sets, namely—

$$x=2,\ y=1,\ z=2,\ w=5, \text{ and } x=1,\ y=3,\ z=1,\ w=5,$$

are found to satisfy all the given equations.

Similarly, w may have the values 4, 3, 2 and 1, and the corresponding values of y and z found, and substituting these sets of values in (1) we will find the corresponding values of x. In all there are 24 such solutions. The reason for this indeterminateness lies in the fact that there is a linear dependence between the given equations.

240. *Proposed by F. E. Tuck, Napa, Cal.*

Derive the formula used in playing the following card trick.

Take out the joker and shuffle the deck. Look at the top card and place it

face down on the table. Suppose it is a six spot. Then deal from the deck the next card, place it on the six spot and count seven. Deal the next and count eight; the next, nine; the next, ten.

Look at the following card and use it as the bottom of a new pile building from the number of its spots up to ten as before. Continue thus until the cards are all arranged in piles, with perhaps some left over. All face cards are considered as ten spots, and, of course, should one fall as the first card of any pile that pile would be complete.

Let x = the number of piles.

y = the number of cards remaining after the last pile is completed.

S = the sum of the spots on the bottom cards of all the piles (face cards counting as ten spots).

$11(x-5)+3+y=S$.

I. *Solution by H. E. Trefethen, Kent's Hill, Me.*

The number of cards in each pile added to the number of spots on the bottom card is 11. Hence the whole number of cards plus the sum of spots on bottom cards $= 11x+y=S+52$. Whence $11(x-5)+3+y=S$.

II. *Solution by I. L. Winckler, Cleveland, O., and John M. Gallagher, Boston, Mass.*

Let a, b, c, ... to x terms, represent the number of spots on the bottom cards.

The number of cards in each group will be—

$10-a+1$, $10-b+1$, $10-c+1$, ... to x terms,

or $11-a$, $11-b$, $11-c$, ... to x terms.

Then $(11-a)+(11-b)+(11-c)+\ldots\ldots$ to x terms $+y=52$;

or $11x-(a+b+c+\ldots\ldots$ to x terms$)+y=52$;

or $11x-S+y=55-3$;

$\therefore\ 11(x-5)+3+y=S$.

Geometry.

241. *Proposed by G. V. Kinney, Buffalo, Minn.*

In the semicircle ABCD express the diameter AD in terms of the chords AB, BC, CD.

I. *Solution by H. E. Trefethen, Kent's Hill, Me., and I. L. Winckler, Cleveland, O.*

$AB^2+BC^2+2AB\cdot BC\cos D = AC^2 = 4R^2+CD^2-4R\cdot CD\cos D$, $\cos D = CD/2R$.

Whence $AB^2+BC^2+AB\cdot BC\cdot CD/R=4R^2-CD^2$, and $R^3-R(AB^2+BC^2+CD^2)/4-(AB\cdot BC\cdot CD)/4=0$. We might express the value of R by Cardan's formula. But since the three roots of this equation are real and unequal, one positive (the required result) and the other two negative, there would be no practical advantage in doing so.

If the chords are equal, the equation gives $R=AB=BC=CD$, as it should.

II. *Solution by N. Anning, Chilliwack, B. C.*

Represent the chords by a, b, c, the diameter by x, and the diagonals of the quadrilateral so formed by y and z.

By Ptolemy's Theorem—

$$bx+ac=yz, \qquad (1)$$

but

$$a^2+y^2=x^2, \qquad (2)$$

and

$$c^2+z^2=x^2. \qquad (3)$$

By squaring (1), and substituting the values of y^2 and z^2 from (2) and (3), we get—

$$x^4-(a^2+b^2+c^2)x^2-2abc\,x=0.$$

Whence $x=0$, or a root of the cubic, $x^3-3s^2x-2m^3=0$, (4)

where $3s^2=a^2+b^2+c^2$ and $m^3=abc$.

The roots of (4) are

$x=p+q,\ \omega p+\omega^2 q,\ \omega^2 p+\omega q,\ (\omega^3=1,\ \omega \neq 1),$
where $p=\sqrt[3]{m^3+\sqrt{m^6-s^6}},\ q=\sqrt[3]{m^3-\sqrt{m^6-s^6}}.$

When $a=25$, $b=33$, $c=39$, the real value of x is 65.

242. *Proposed by H. E. Trefethen, Kent's Hill, Me.*

If a, b, c are the sides of a triangle, and $5(a^2+b^2+c^2)=6(ab+bc+ca)$, show that the incircle passes through the centroid of the triangle.

I. *Solution by N. Anning, Chilliwack, B. C.*

$$5(a^2+b^2+c^2)=6(ab+bc+ca)$$

$$\therefore 8(a^2+b^2+c^2)=3(a^2+b^2+c^2+2ab+2ac+2bc)=3(a+b+c)^2$$

$$\frac{a^2+b^2+c^2}{3}=\frac{(a+b+c)^2}{8}=\frac{s^2}{2} \qquad (1)$$

If G be the centroid of the $\triangle$, $\dfrac{a^2+b^2+c^2}{3}=AG^2+BG^2+CG^2$.

If P be any point in the plane of the $\triangle$,

$$3GP^2+AG^2+BG^2+CG^2=AP^2+BP^2+CP^2 \qquad (2)$$

Now if P be the center of the incircle, $AP^2=(s-a)^2+r^2$, and similarly for BP and CP. Combining (1) and (2)

$$3GP^2+\frac{s^2}{2}=(s-a)^2+r^2+(s-b)^2+r^2+(s-b)^2+r^2,$$

$$\text{or } 3GP^2=3r^2+\left[3s^2-2s(a+b+c)+a^2+b^2+c^2-\frac{s^2}{2}\right]$$

$$=3r^2+\left[3s^2-4s^2+\frac{3}{2}s^2-\frac{s^2}{2}\right], \text{ from (1),}$$

$$=3r^2.$$

The distance of G from P is r, the radius of the incircle. Hence, the incircle passes through the centroid.

II. *Solution by the Proposer.*

Let O be the center of the incircle, OP perpendicular to the shortest side AB, OH to AC, and N the midpoint of AC. BN cuts the circle in Q and S, Q being nearer to B. Put $x=BS$, $y=BQ$. Then $HN=(a-c)/2$, $BN^2=(2a^2+2c^2-b^2)/4$, $BQ \cdot BS=xy=BP^2=(a-b+c)^2/4=ac-(a^2+b^2+c^2)/6$, since $5(a^2+b^2+c^2)=6(ab+bc+ca)$.

$NS \cdot NQ=(BN-x)(BN-y)=HN^2=(a-c)^2/4$ or $(\sqrt{2a^2-b^2+2c^2}/2-x)(\sqrt{2a^2-b^2+2c^2}/2-y)=(a^2-2ac+c^2)/4$. From this and the value of xy above we find $x+y=(a^2-5b^2+c^2+18ac)/6\sqrt{2a^2-b^2+2c^2}$, and $x-y=(7a^2+b^2+7c^2-18ac)/6\sqrt{2a^2-b^2+2c^2}$.

Hence $x=BS=\sqrt{2a^2-b^2+2c^2}/3=2BN/3$.

III. *Solution by I. L. Winckler, Cleveland, O.*

Let O be the center of inscribed circle, G be the centroid. Draw median CD through G; CH, OF, and GE, perpendicular to AB, and GL perpendicular to OF.

$$AE=AH+\tfrac{2}{3}HD=AH+\tfrac{2}{3}(AD-AH)=\tfrac{1}{3}AH+\tfrac{2}{3}AD$$

$$=\frac{b^2+c^2-a^2}{6c}+\frac{c}{3}=\frac{b^2+3c^2-a^2}{6c}$$

$$AF=\frac{b+c-a}{2}$$

$$\therefore EF=GL=AE-AF=\frac{b^2-a^2-3bc+3ac}{6c}$$

Also $GE=\tfrac{1}{3}CH=\dfrac{2S}{3c}$, where $S=$ area ABC.

The equation of the inscribed circle, referred to the axes AB and OF is $x^2 + (y - r)^2 = r^2$, r being the radius.

This reduces to $x^2+y^2-2ry=0$.

Substituting the coördinates of G in the left hand member, we have

$$\left(\frac{b^2-a^2-3bc+3ac}{6c}\right)^2 + \frac{4S^2}{9c^2} - \frac{4S^2}{3cs}, \left(s=\frac{a+b+c}{2}\right)$$

This reduces to $c^2[5(a^2+b^2+c^2)-6(ab+ac+bc)]$, and this is zero if $5(a^2+b^2+c^2)=6(ab+ac+bc)$.

243. *Selected.*

If a circle passing through one of the angles A of a parallelogram ABCD intersect the two sides AB, AD again in the points E, G and the diagonal AC again in F, then

$$AB{\cdot}AE+AD{\cdot}AG=AC{\cdot}AF.$$

I. *Solution by I. L. Winckler, Cleveland, O.*

$\angle BCA=\angle CAD=\angle FEG$, each measured by ½ arc FG. Similarly, $\angle FGE=\angle BAC$.

$\therefore$ $\triangle ABC = \triangle ADC$ is similar to $\triangle FEG$.

$\therefore$ AC:EG=AB:FG=AD:EF (1)

From the inscribed quadrilateral AGFE we have,

$$AG{\cdot}EF+AE{\cdot}FG=AF{\cdot}EG \quad (2)$$

Substituting the values of EF and FG from (1) in (2) we have

$$AG{\cdot}AD+AE{\cdot}AB=AC{\cdot}AF.$$

II. *Solution by H. E. Trefethen, Kent's Hill, Me.*

Circle BEF cuts AC in H. Produce EF to cut CD at K. G, F, K, D are concyclic and the circle cuts AC in I. $CI{\cdot}CF=CK{\cdot}CD$ and hence $CI/CD=CK/CF=AE/AF$, $CI{\cdot}AF=AE{\cdot}CD$ $(CD=AB)$

Also $AI{\cdot}AF=AG{\cdot}AD$.

Whence by adding $AC{\cdot}AF=AB{\cdot}AE+AD{\cdot}AG$.

III. *Solution by C. A. Perrigo, Dodge, Neb.*

Draw Gx making $\angle AGx=\angle EGF$.

Now triangles AxG, EFG and ADC are similar.

$\therefore$ Ax:AD=AG:AC or $Ax{\cdot}AC=AD{\cdot}AG$. (1)

Also DC:AC=GF:GE. (2)

But triangles GxF and GAE are similar.

$\therefore$ xF:AE=GF:GE. (3)

$\therefore$ xF:AE=DC:AC. (4)

$\therefore$ xF:AE=AB:AC or $xF{\cdot}AC=AB{\cdot}AE$. (5)

Adding (1) and (5)—

$Ax{\cdot}AC+xF{\cdot}AC=AD{\cdot}AG+AB{\cdot}AE$.

or $AF{\cdot}AC=AD{\cdot}AG+AB{\cdot}AE$.

$\therefore$ $AB{\cdot}AE+AD{\cdot}AG=AF{\cdot}AC$.

Correction by J. A. Whitted, Abingdon, Ill., and E. M. Dow, Brighton, Mass.

On page 266 of the March issue of SCHOOL SCIENCE AND MATHEMATICS, in the second solution of problem 230, this statement appears: "Now since the sum of two squares cannot equal the sum of two other or different squares." Clearly this statement is *not* true, as a long list of cases might be cited where $a^2+b^2=c^2+d^2$ and yet all four squares be different; e. g.,

$$12^2+1^2=9^2+8^2,$$

$11^2+2^2=10^2+5^2$, etc., etc.

In general, the sum of two squares suggests the square of the hypotenuse of a right triangle. Suppose a right triangle be constructed on a given line

as hypotenuse, then the vertices of the possible triangles will lie on a circle. It is quite evident that only rarely would the chords forming the right angle in any one case equal the chords forming another of the right angles. In fact, the chords would be equal only when the altitudes of the triangles formed were equal.

Credit for Solutions Received.

Geometry 233—G. I. Hopkins (1).

Algebra 234—E. C. Wilson, John Gaub, E. E. Watson, M. W. Wilson (4).

Algebra 235—E. E. Watson (1).

Geometry 236—M. W. Wilson (1).

Algebra 239—N. Anning, O. K. Lie (2 solutions), W. Thompson, H. E. Trefethen, J. A. Whitted (2 solutions), I. L. Winckler (8).

Algebra 240—N. Anning, J. M. Gallagher, H. E. Trefethen, F. E. Tuck, I. L. Winckler (5).

Geometry 241—N. Anning, G. V. Kinney, H. E. Trefethen, I. L. Winckler (4).

Geometry 242—N. Anning, H. E. Trefethen, I. L. Winckler (3).

Geometry 243—C. A. Perrigo, H. E. Trefethen, I. L. Winckler (3).

Total number of solutions, 30.

PROBLEMS FOR SOLUTION.

Algebra.

249. *Proposed by John Gaub, Ithaca, N. Y.*

Solve $18^{4(2-x)}=(54\sqrt{2})^{3x-2}$

250. *Selected.*

If a, b, c are positive and unequal, show that the roots of

$$x^3-(a^2+b^2+c^2)x-2abc=0$$

are real and unequal, one positive and the other two negative.

251. *Proposed by Ira M. DeLong, Boulder, Colo.*

Let $a\sqrt[m]{A}$, $b\sqrt[n]{B}$ be equal simple surds in their simplest form; prove $a=b$, $A=B$, $m=n$.

Geometry.

252. *Proposed by N. Anning, Chilliwack, B. C.*

If a triangle have a point at which all the sides subtend equal angles, find the distances of this point from the vertices.

253. *Selected by H. E. Trefethen, Kent's Hill, Me.*

A man built an oven to burn charcoal in on a circular bottom, ten feet in diameter. While building it he kept one end of a pole, ten feet long, always against the place he was working at, and the other end in that point of the circumference of the bottom opposite to him. Find the capacity of the oven *by the methods of pure geometry* (without the use of calculus or *the center of gravity*).

A GRAPHICAL SOLUTION OF.

$$F(x) = x^n + bx^{n-1} + cx^{n-2} + dx^{n-3} + \dots\dots\dots = 0$$

by T. M. Blakslee, Ames, Ia.

First let us consider an arithmetical method of finding $F(r)$, that is,

$$\begin{array}{llll}
\multicolumn{4}{l}{r^n + br^{n-1} + cr^{n-2} + dr^{n-3} + \dots\dots\dots} \\
1 + b & + c & + d & \\
\quad r & r^2 + br & r^3 + br^2 + cr & \\
1,\ r + b, & r^2 + br + c, & r^3 + br^2 + cr + d & \\
a^1,\ b^1, & c^1, & d^1 &
\end{array}$$

It is evident that d' is $x^3 + bx^2 + cx + d$ with r substituted for x.

If $F(x) = x^3 - 6x^2 + 11x - 6 = 0$

$$\begin{array}{rrrrl}
1 & -6 & +11 & -6 & \lfloor 2 \\
 & +2 & -8 & +6 & \\
1 & -4 & +3 & 0 & \therefore F(2) = 0 \text{ } i.\,e., \text{ 2 is a root of } F(x) = 0 \\
1 & -6 & +11 & -6 & \lfloor 4 \\
 & +4 & -8 & +12 & \\
1 & -2 & +3 & +6 & \therefore F(4) = 6
\end{array}$$

While we cannot express $\sqrt{2}$ numerically, yet it is graphically represented by the diagonal of the square on the unit. So the method given here has similar advantages when the roots are incommensurables and it must be added that it has similar disadvantages.

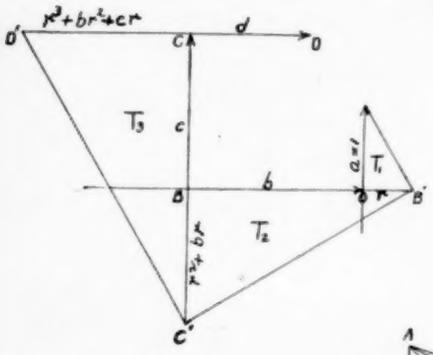


Fig. 1.

Fig. 2.

AOBCD is the *frame* of the equation, the sucessive strokes being the coefficients of the equation. OB′ is r, the value of x to be substituted. AB′C′D′ is the *path of substitution*, its successive strokes being at right angles as are those of the *frame*. It is easily seen that the triangles AOB′, B′BC′, C′CD′, . . . or T_1, T_2 T_3, . . . are similiar. As in T_1 the side opposite angle A is r times that adjacent to it, so it is in T_2, T_3 . . . Hence the values of Fig. 1 leading to

$$D'D = r^3 + br^2 + cr + d.$$

If r is a root, D′ falls at D.

Fig. 2 is the frame of $x^3 - 6x^2 + 11x - 6 = 0$. To determine B′ so that D′ falls at D. Take three rectangular cards. Place an edge of one of

them through A and a point near B'. Place a second card against this to determine C', then the third against the second to determine D' at D. Slide the cards the one against the other till B' and C' are located, A and D remaining fixed. This will be the case when B' is at +1, +2, and +3. If it be at 4, D'D=+6.

In retracing the *frame*, starting with AO, the strokes (*a* and *b*), (*e* and *f*), and so on are reversed, the others are not.

Show that the roots of $x^3-3x^2-2x+5=0$ are 1.20........, 3.13......., and —1.33.......

Draw the *frame* of $x^{10}+2x^9-3x^8+x^7+4x^6+5x^5-3x^4+4x^3-2x^2+x-2=0$.

SCIENCE QUESTIONS.

By Franklin T. Jones,

University School, Cleveland, Ohio.

Our readers are invited to propose questions for solution—scientific or pedagogical—and to answer the questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.

Questions and Problems for Solution.

48. *Proposed by J. Hawley Aikin, Springfield, Mass.*

A river forty feet wide is dammed. After the water has adjusted itself, it is found to be ten feet deeper on the upper side. Find the unbalanced pressure against the dam.

The following paper was set by Princeton University in June, 1910. Please answer questions consecutively numbered with the above.

PRINCETON UNIVERSITY FRESHMAN ENTRANCE EXAMINATIONS.
JUNE, 1910.

Physics.

A—ANSWER ANY FIVE.

1. State Newton's laws of motion—What is the measure of the so-called "centrifugal force"?

Where on the earth would a given mass have the greatest weight? Why?

2. What is the mechanical advantage of any machine? What is its efficiency?

Show that there is no saving of work in using an inclined plane. Why is it desirable to use such a plane?

State the law of equilibrium of moments of force.

3. Show, as a result of the fact that light travels in straight lines, that the intensity of illumination varies inversely as the square of the distance from the light to the body iluminated.

Define the following terms: focus, focal length, conjugate focal lengths. State the equation connecting these quantities.

4. Describe the "spheroidal state" and explain its production.

Describe the process of fractional distillation, and state what determines the ease, or difficulty, of separating two liquids which are mixed.

5. Define the following: electrolysis, electroltyte, cathode, ion.

Describe the actions which occur when a current is passed between two platinum electrodes immersed in a copper sulphate solution.

How does the force between two magnetic poles vary with increasing distance?

6. What is sound? What is an echo? What is meant by the statement, "two sounding bodies are in resonance"? What is the purpose of the sounding board of a piano?

What determines the quality of a musical tone? What the intensity?

B—ANSWER ANY FIVE.

49. What is the potential energy of a body whose *weight* is 640 lbs., when it is raised 60 ft.?

The body is allowed to fall freely. What is its kinetic energy after it has fallen 30 ft.? After 60 ft.? Let "g" = 32 ft. per sec. per sec.

50. Steam is admitted to the cylinder of an engine in such manner that the average pressure is 120 lbs. per sq. in. The area of the piston is 54 sq. in. and the length of stroke is 12 inches. How much work can be done during a single complete stroke, assuming that steam is admitted to both sides of the piston in succession?

What is the horse power of the engine when it is making 300 strokes per minute?

51. A stretched wire gives a middle C when plucked. A bridge is put at the middle of the wire, while, at the same time, the tension is made four times what it was. What tone will be produced by either half of the wire?

What are beats? Show by a diagram how they are produced.

52. Calculate by the law of Dulong and Petit the specific heat of a substance whose atomic weight is 108.

53. Four kilograms of iron at 400°C are dropped into 1 kilogram of broken ice and 3 kilograms of water at O°C. What is the result? Take .12 as the specific heat of iron and 80 as the heat of fusion of ice.

How can you prove that the electric charge on a body in equilibrium is wholly on the surface?

54. A loop of wire whose area is 1,000 sq. cm. is removed in .5 second from a magnetic field whose average strength is 2,000 lines per sq. cm. What e. m. f. in volts will be generated?

55. Find the principal focal length of a concave mirror, two of whose conjugate focal lengths are 40 and 50 cm. Find the radius of curvature.

A beam of white light is passed through a prism and a spectrum is produced. Which color is deflected most? What does this indicate as to the velocity in the prism of the various colors?

Solutions.

43. *Proposed by J. C. Packard, Brookline, Mass.*

A right circular cylinder, 2″ x 2″ specific gravity 0.7, floats in fresh water with its axis horizontal. How much must the cylinder be shortened to make it float upright?

Solution by J. G. Gwartney, Mountain View, Cal.

The center of gravity of the part above water seeks the lowest possible position. When floating horizontally the center of gravity of the part above water lies at the point determined by the intersection of plane through the center of the cylinder perpendicular to the surface of the water, the plane through the center of gravity of the part above horizontal to the surface of the water and the plane bisecting the cylinder forming a right section, and is constant.

The center of gravity when floating on end is one-half of three-tenths of the length of the cylinder, or in this problem, .3″. Then to make the cylinder float on end it is necessary to make this distance less than the constant distance of center of gravity when floating horizontally.

Calculate the distance using the formula, area of a segment of a circle equals $\frac{4h^2}{3}\sqrt{\frac{D}{h}-.608}$ where h is altitude of segment and D is diameter.

The area is known, being .3 the right section of the cylinder, or .94 sq. in. for whole segment above water and .47 sq. in. for the segment above the

center of gravity. Determining '*h*' and "*h*" from the formula we find '*h*' equals .65 in. and "h" .41 in. nearly. The difference .24 in.

Hence the center of gravity when floating on end must be lowered at least the difference between .3 in. and .24 in. or .06 in., i. e., .4 in. must be cut from the cylinder.

44. *From an examination paper of Morris High School, New York.*

In the course of a stream is a waterfall 22 feet high. It is shown by measurement that 450 cubic feet of water per second pour over it. How many foot pounds of energy could be obtained from it? What horse power? What becomes of this energy if not used in driving machinery?

Solution by J. E. Gwartney, Mountain View, Cal.

Multiply the volume of water (450 cu. ft.) by the height of waterfall and this product by the weight of one cubic foot of water (62.5 lbs.). This last result should be multiplied by the per cent of efficiency of the wheel used. This result should then be divided by 550 to reduce to horse power. The horse power will be 1,125 multiplied by the efficiency, or 20 per cent, giving 225 horse power as a fairly high estimate.

If not used to turn machinery the power is changed to heat and passes off in the air or is taken up by the water and carried away.

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Canadian Teacher, Toronto, Can.
Colorado School Journal, Denver, Col.
Educator-Journal, Indianapolis, Ind.
Florida School Exponent, Miami, Fla.
Journal of Education, Boston, Mass.
Kindergarten-Primary Magazine, New York City.
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Missouri School Journal, Jefferson City, Mo.
Midlands Schools, Des Moines, Iowa.
Mississippi School Journal, Jackson.
Nebraska Teacher, Lincoln, Neb.
New Mexico Journal of Education, Santa Fe, N. M.
North Carolina Journal of Education, Durham, N. C.
Ohio Educational Monthly, Columbus.
Ohio Teacher, Athens, O.
Pennsylvania School Journal, Lancaster, Pa.
Popular Educator, Boston, Mass.
Primary Educator, Boston, Mass.
School and Home Education, Bloomington, Ill.
School Bulletin, Syracuse, N. Y.
School Century, Oak Park, Ill.
School Education, Minneapolis, Minn.
School Journal, New York, N. Y.
School News, Taylorville, Ill.
School Science and Mathematics, Chicago.
Southern School Journal, Lexington, Ky.
Texas School Journal, Dallas.
Texas School Magazine, Dallas, Tex.
Volta Review, Washington, D. C.
Western School Journal, Topeka, Kan.
Western Teacher, Milwaukee, Wis.
Wisconsin Journal of Education, Madison.

REPORT OF THE MINNEAPOLIS MEETING OF THE AMERICAN FEDERATION OF TEACHERS OF THE MATHEMATICAL AND NATURAL SCIENCES.

(Concluded.)

Report of the Association of Teachers of Mathematics in the Middle States and Maryland.

This association has had a year of steady progress. The meetings of the general association and of its sections have been full of enthusiasm and of help for the teacher.

A number of committees have been at work on various problems, the one of broadest scope being, perhaps, that on the Algebra Syllabus. This committee has reported on Elementary, Intermediate, and Advanced Algebra, and the report has been amended and accepted by the association. This report will be published in the next number of the *Mathematics Teacher*.

A catalogue of members is in course of preparation. The names of those who are behind in their dues are being weeded out, and the membership is being put on as sound a basis as possible. The number of new members recently added is very large and will add considerably to the influence of the association.

The *Mathematics Teacher* has continued to gain in influence and in popularity, and there is no longer any doubt of its having proved the need of such a magazine.

The association has been invited to hold its annual meeting in conjunction with the Association of Colleges and Preparatory Schools of the Middle States and Maryland, and has accepted for next fall. The spring meeting will be held in New York.

HOWARD F. HART, *Secretary*.

Report of the Association of Mathematical Teachers in New England.

The association has held during the present year three formal meetings. The midwinter meeting at Hartford, Conn., February 26, was held in connection with the meeting of the Connecticut Association of Classical and High School Teachers. Here Mr. John C. Packard read an account of certain personal details in connection with John Perry, and gave an interesting survey of the main features of the Perry Movement as they appeared to him on his visit to England. Mr. Eugene Randolph Smith delivered by invitation an address on "The Syllabus Method of Teaching Geometry," and Mr. George W. Evans spoke on "Simpson's Rule for Plane Areas."

The eighth spring meeting was held in Cambridge, Mass., April 16, and included two notable addresses—one on "Arithmetic for Industrial Schools," by Mr. William H. Dooley of the Independent Industrial School of Lawrence, Mass.; and the other, "Mathematics for Agricultural Students," by Professor Charles A. Wheeler of the Connecticut Agricultural College, Storrs, Conn. Six practical teachers gave their advice as to special methods of teaching algebra in the entering class of the high school.

The eighth annual meeting, held in Boston on Saturday, December 3, presented two addresses, one by Professor J. C. Tracy of Yale University on "Efficiency in Calculation," and the other by Mr. Peter F. Gartland of the English High School in Boston on "Two Experiments on Grammar School Graduates."

Most of the work of this year was devoted to examining possible adjustments between the modern demand for practical instruction and the scientific

necessities of mathematical education. The addresses delivered before the association have borne with great emphasis on practical applications and practical details of work. The association is not committed, by any means, to any of the different kinds of reform in mathematical instruction that have been brought forward, but a disposition to examine all such propositions has shown itself in many ways, notably in the appointment of a committee whose duty it is to consider the question whether there is any reason for remodeling the secondary school course in mathematics, in content or in order of development; this committee to report at some meeting of the association next year. The discussions that have taken place in the meetings have enlisted the attention of many of the college men who are members, and the association has had at various times the benefit of their judgment upon these matters. It is uncertain, however, whether the association will commit itself either one way or the other during the coming year. GEO. W. EVANS, *Secretary*.

Report of the Central Association of Science and Mathematics Teachers.

The Central Association of Science and Mathematics Teachers has performed a very profitable year's work. Committees appointed a year ago have carried on their investigations during the year, and made reports at the annual meeting.

Reports were presented to the association at the annual meeting in Cleveland, O., November 25 and 26, by a committee on "Fundamentals Common to the Various Sciences and Mathematics," by a committee on "Coöperative Experiments in Teaching Science," and by a committee on "The Relation of Elementary School Nature Study to Secondary School Science." An address was given by Dr. Dayton C. Miller, Case School of Applied Science, on "Sound Waves: Their Meaning, Registration, and Analysis." An address was given by Dr. Harvey W. Wiley, Washington, D. C., on "Food Facts which Every Citizen Should Know." Also many valuable reports and addresses were given before the various sections of the association.

All of these reports and addresses will be printed in the annual volume of Proceedings, which has been made a permanent publication of the Central Association.

The annual report of the secretary-treasurer for the year ending November 23, 1910, showed that the Central Association had at that date a paid-up membership of 488, and a total membership of 575, showing a large increase in the membership of the association during the year.

The next annual meeting will be held in Chicago in November, 1911.

JAS. F. MILLIS, *Secretary*.

Report of the New England Association of Chemistry Teachers.

The thirty-sixth meeting of the association was held at Harvard University on December 4, 1909. After the reports of standing committees, the election of officers was held. Ostwald and Morse's "Elementary Modern Chemistry," Emery's "Elementary Chemistry," and Segerblom's "First Year Chemistry" were reviewed. Mr. L. G. Smith spoke on "Some Experiences of an American Teacher in the German Higher Schools." Professor T. W. Richards's address was on "The Value of Investigation to the Teacher of Chemistry."

The thirty-seventh meeting was held at the Lowell Textile School on February 12, 1910. The morning was spent in observing the equipment

and the methods employed in the teaching of textile chemistry. At the afternoon session Professor Olney gave a very interesting talk on the work of the school. Godfrey's "Elementary Chemistry" and Biltz's "Introduction to Experimental Inorganic Chemistry" were reviewed. The report of the delegates to the American Federation meetings was made by Wilhelm Segerblom. Professor Newell presented the report of the committee on current events.

The thirty-eighth meeting was held at the Harvard Medical School on April 16, 1910. The meeting opened with the reports of the various standing committees. Under new business Mr. Segerblom called attention to the American Federation report in SCHOOL SCIENCE AND MATHEMATICS. Attention was also called to the fact that delegates had been appointed by the Federation to consider the possibility of changing the College Entrance Board chemistry syllabus. The principal address was on "The Function of Enzymes in the Chemistry of Life," by Dr. A. W. Peters. This was followed by a short address by Dr. C. A. Scott on "The Psychology of Science Teaching." The laboratories of the Medical School were visited at the close of the morning session. The afternoon was spent at the Carnegie Nutrition Laboratory, where Mr. Carpenter, the chemist in charge, described the laboratory and its special apparatus.

Through the kindness of President A. Lawrence Lowell, a course on the "Chemistry of Food" was given by Professor A. G. Woodman.

The twenty-ninth meeting of the association was held at Boston University, October 22, 1910. After the reading of the reports, Williams's "Essentials of Chemistry" and Meade's "Chemist's Pocket Manual" were reviewed. The opening address was given by Professor H. W. Morse on "The Experimental Basis of the Theory of Radio-activity." Mr. W. G. Whitman described some interesting new experiments. The closing address was by Professor Latham Clark on "Some Phases of the German Chemical Industry."

The following officers were elected for the year 1910-11: President, Mr. F. C. Adams; vice-president, Mr. C. W. Goodrich; secretary, Mr. E. S. Bryant; treasurer, Mr. A. M. Butler; executive committee, Prof. F. L. Bardwell, Mr. H. Bisbee, and Mr. G. A. Cowen.

EDWARD S. BRYANT, *Secretary.*

Report of the Missouri Society of Teachers of Mathematics and Science.

Our society has held two meetings during the past year—one at Kirksville, Mo., in May, and one in connection with the State Teachers' Association at St. Joseph, Mo., in November. We have made arrangements with the State Teachers' Association to have reports of our meetings published in connection with their annual report and to have reprints made for the use of members of the society and others who may wish them.

Our membership for 1909-10 was 114. Our total membership for this year cannot be determined at this time, since not all of our members have renewed their membership. L. D. AMES, *Secretary.*

ARTICLES IN CURRENT MAGAZINES.

American Forestry for March: "White Pine in New Hampshire," three pictures; "The People's Possessions in the Appalachian Forest," Thomas Nelson Page; "Harvesting the Annual Seed Crop," Sidney Moore; "Growing Trees from Seed," C. R. Pettis; "Reforestation in Massachusetts," F. W. Rane; "The Passage of the Appalachian Bill," Text of the Bill as Enacted.

Botanical Gazette for March: "Causes of Vegetative Cycles," Henry C. Cowles; "Studies of Jamaican Hymenopyllaceae," Forrest Shreve; "Wax Seal Method of Determining the Lower Limit of Available Soil Moisture," Lyman J. Briggs and H. L. Shantz; "Temperature Coefficient of the Duration of Life of Barley Grains," T. Harper Goodspeed.

Electric Journal for March: "Switch-Board of Congressional Light, Heat, and Power Plant," C. H. Sanderson and M. C. Turpin; "History of the Air Brake," George Westinghouse; "Motor Applications in the Textile Industry," Albert Walton; "Some Steam Turbine Considerations," Edwin D. Dreyfus; "Weight Transfer in Electric Cars and Locomotives," G. M. Eaton; "Electrostatic Stresses and Ground Connections," C. Fortescue; "Notes on Factory Lighting," C. E. Clewell.

Journal of Geography for March: "Geographical Influences in the Development of Ohio," Frank Carney; "Mineral Resources of Ohio," J. A. Bownocker; "The Ohio Valley in Relation to Early Ohio History," George W. Hoke; "The Development of Cincinnati," Irving R. Garbutt; "Lake Erie and its Southern Ports," W. E. Durstine; "The Islands of Lake Erie," W. P. Holt; "The Teaching of Physical Geography in Ohio," George R. Twiss; "Notes on Ohio's Railroads and Industries," G. D. Hubbard; "Geographic Influences Affecting Early Cincinnati," N. M. Fenneman; "Present Problems in Elementary School Geography," W. M. Gregory.

Mining Science for March 2: "Time and Temperature Elements in the Roasting of Sulpho-Telluride Ores;" "The Geology of Petroleum;" "Developments and Mining Conditions in the Porcupine District, Canada;" "Explosion-Proof Motors for Coal Cutting Machines."

Nature-Study Review for March: "A Year With Katydids," Meta Schlundt; "Nature Calendars," Chester A. Mathewson; "Farm Calendar," O. D. Center; "Calendar Forms," F. L. Charles; "Observations on High School Agriculture," Leroy Anderson; "Creed on Teaching Nature-Study," Elliot R. Downing.

Open Court for March: "On the Foundation and Technic of Arithmetic" (continued), George Bruce Halsted.

Photo-Era for March: "The Oil-Process," William H. Kunz; "Art in Photography," Studio Light; "Coloring Photographs with Transparent Water-Colors," B. I. Barrett; "Photography at Night," Frank Sayles Dart; "Color-Photography *vs.* Painting," Frederick H. Evans; "Some Observations on Ozobrome," William Findlay; "Materials for the Tropics," Dr. Tempest Anderson; "A New Gelatine Pigment-Process for Pictorial Workers," Malcolm Arbuthnot.

Photo-Era for April: "Some Notes on Home-Portraiture," Katherine B. Stanley; "Successful Speed-Work," C. H. Claudy; "A New Method of Tank-Development," Harold Baker; "The Coming Camera," Percy M. Reese; "Bathed Plates for High-Speed Ortho. Work," The Red Lamp; "The Transformation of Ugliness," the Picture and Art Trade; "A Photographic Trip to Ancient Chester," Ernest M. Astle; "An Appreciation of R. S. Kauffman," R. S. Smith.

Physical Review for March: "The Construction of Standard Cells and a Constant Temperature Bath," G. A. Hulett; "A Study of the Joule and Wiedemann Magnetostrictive Effects in Steel Tubes," S. R. Williams; "The Causes of Zero Displacement and Deflection Hysteresis in Moving Coil Galvanometers," Anthony Zeleny; "Remarks on a Paper by J. S. Stokes on 'Some Curious Phenomena Observed in Connection with Melde's Experiment;'" C. V. Raman; "The Small Motion at the Nodes of a Vibrating String," C. V. Raman; "Note on Crova's Method of Heterochromatic Photometry," Herbert E. Ives; "A New Method of Producing Ripples—Optical Analogies," A. H. Pfund; "Effect on the Cathode Fall in Gases Produced by the Evolution of Gas from the Cathode," L. A. Jones.

Popular Astronomy for April: "The Truth About the Gyroscope," Hyland C. Kirk; "The Origin of Lunar Surface Formations," Walter Goodacre; "The Moon, Photographed by M. M. Loewy and Puiseux," Plate IX, Opposite 218; "Long-Range Weather Forecasting, and Its Methods," J. S. Ricard; "Vegetal Life on Mars," Latimer J. Wilson; "Alpha Hydrogen in the Star D. M. + 30° 3639," Monroe B. Snyder; "The Sun-Path Model," Joseph F. Morse; "The Probable Errors of Adjusted Measurements," LeRoy D. Weld.

Popular Science Monthly for April: "The Genesis of the Law of Gravity," John C. Shedd; "Edward Palmer," William Edward Safford; "Freud's Theories of the Unconscious," William Chase; "Impressions of Military Life in France," Albert Leon Guérard; "Reality and Truth," T. D. A. Cockerell; "The Cost of Living," Henry Pratt Fairchild; "Alcohol—Its Use and Abuse," Graham Lusk; "Scientific *versus* Personal Distribution of College Credits," President William T. Foster.

Psychological Clinic for March: "Problems of the Social Worker," Anna Cooper Campion, University of Pennsylvania; "Retardation Statistics from the Smaller Minnesota Towns," Freeman E. Lurton, Superintendent of Schools, Anoka, Minn.; "Elimination and Retention of Pupils," Edward P. Cummings, Superintendent of Schools, Lansing, Mich.

Scientific American Supplement for March 11: "The Chemistry of Cellulose," Carl G. Schwalbe; "Blue Printing by Machinery," George J. Jones; "Magnet Alloys," H. A. Knowlton; "New Methods in Astronomy," F. W. Henkel.

School Review for March: "The American Idea," Grant Showerman; "The Fundamental Principles of Continuation Schools," Georg Kerschensteiner; "Church, State, and School in France. I. The Foundations of the Public School in France," David Saville Muzzey.

School World for March: "Examinations and National Efficiency;" "Education in Australia," H. S. Carslaw; "A Schoolmasters' Fund;" "Scouting for Boys in Higher Schools," Harold F. Beeton; "The Pursuit of Knowledge. I. Mosquitoes and Man," R. A. Gregory; "A Room for the Teaching of Geography," J. Fairgrieve; "Preliminary Investigations on Memory," E. O. Lewis; "Examinations in Their Bearing on National Efficiency," P. J. Hartog; "Text-Books in Geography."

Teachers College Record for March: "The Teaching of Primary Arithmetic—A Critical Study of Recent Tendencies in Method," Henry Suzzallo.

SUGGESTION FOR PREVENTING MINE ACCIDENTS.

By John L. Cochrane.

The selection of state mine inspectors by popular vote must be stopped if there is to be a reduction of accidents in the coal and metal mines of the United States, according to a statement made before the students of Case School of Applied Science by Dr. Joseph A. Holmes, director of the Federal Bureau of Mines.

The director was giving a number of suggestions which, if followed up, would mean a reduction of the number of accidents. The mines of this country exact a toll of more than 3,000 lives yearly.

"The state mine inspectors should have greater permanence in office and freedom from political and other outside influences. Their selection and continuance in office should depend upon their training and experience. They should be examined by a non-political board of mining men. They should be appointed upon the recommendation of such a board from the applicants that have shown the highest skill and best experience. Politics should have nothing whatever to do with their selection or their continuance in office. The inspectors should have better support in the way of compensation. In fact, the salary and other conditions should be such as to enable the state to secure the best possible type of men for this important work."

Other methods of reducing the number of accidents were suggested as follows:

The use at each mine of a limited number of men well trained and experienced concerning the best methods of using explosives, electricity, the handling of gases and coal dust, the methods of timbering, with a view to preventing falls of roof; the methods of preventing and extinguishing mine fires; and the methods of rescue and first aid work. These trained men can serve to good advantage as special inspectors or foremen of each mine company.

There must be active, determined coöperation between the miners and the mine management and the state mine inspectors in the enforcement of the mine rules and regulations, and the punishment of every person, whether mine worker or mine manager, who disobeys these rules and regulations.

The continuance and extension of the investigations and inquiries such as are now being conducted by the Government concerning the causes of mine accidents and methods of prevention.

The prompt distribution of all such information as can be obtained on this subject from these and other sources among the miners and officials.

BOOKS RECEIVED.

Elementary Practical Mechanics, by J. M. Jameson, Pratt Institute; XII+321 pages. 13x19 cm. Longmans, Green & Co., New York.

New York State Year-Book of Legislation, Edited by Clarence B. Lester; 1035 pages. 16x23 cm. Price, $1.00. University of the State of New York, Albany.

Catalogue of High School and College Text-Books, with complete index and price list; XXIV+519 pages. 14x19 cm. Ginn & Co., Boston.

A Text-Book of Integral Calculus, by G. Prasad, 1910. Pages 241. 15x22 cm. Longmans, Green & Co., New York and London. Price, $1.50.

A Text-Book of Differential Calculus, by G. Prasad, 1909. Pages 161. 14x23 cm. Longmans, Green & Co. Price, $1.50.

An Elementary Text-Book of Physics. Part I. General Physics, by R. Wallace Stewart, 1910. Pages 414. London, Charles Griffin & Co. J. B. Lippincott, Philadelphia. Price, $2.00.

Tables for the Determination of Minerals by Means of Their Physical Properties, Occurrences, and Associates, by Edward Henry Kraus and Walter Fred Hunt, University of Michigan. 254 pages. 16x24 cm. 1911. $2.00, net. McGraw-Hill Book Company, 239 W. 39th St., New York.

A Laboratory Manual of Inorganic Chemistry, by Eugene C. Bingham and George F. White, Johns Hopkins University. VIII+146 pages. 1911. $1.00 net. John Wiley & Sons, New York.

Illinois Arbor and Bird Day issued by the Superintendent of Public Instruction. 96 pages. 15x23 cm. Illinois State Journal Company, Springfield.

Essentials of Latin for Beginners, by Henry Carr Pearson, Teachers' College, New York. 320 pages. 14x19 cm. 90 cents. American Book Company, Chicago.

The Animals and Man. An Elementary Text-Book of Zoölogy and Human Physiology, by V. L. Kellogg, 1911. Pages 495. Henry Holt & Co., New York. Price, $1.25.

The Problem of the Angle Bisectors, by R. P. Baker, 1911. Pages 98. University of Chicago Press. Price, $1.10, postpaid.

BOOK REVIEWS.

College Mathematics Notebook, by Robert E. Moritz, University of Washington. 100 pages. 20x27 cm. Price, 80 cents. 1911. Ginn & Co.

This notebook is adapted for use in all classes in college mathematics, and may be used to advantage in secondary schools where advanced algebra and trigonometry are taught. There are three pages of formulas, two pages of tables, and a page of standard curves.

The squared paper is ruled in centimeters and millimeters. It is printed in a green color which permits the small squares to be counted easily and does not obscure the graphs. In addition to the rectangular coördinate paper there are several pages of polar coördinate paper. H. E. C.

Design and Representation. A Handbook for Teachers, New York State Education Department. 33 pages. 44 plates. 14x22 cm. paper.

A most excellent little book which has been prepared very largely for the purpose of assisting teachers in drawing in the work of instruction, as shown in the New York state syllabus for secondary schools. The subject of freehand drawing, including design and representation has been kept entirely distinct from mechanical drawing. In order to use the handbook intelligently the teacher must possess a thorough knowledge of the art of drawing. The book is splendidly gotten up, the illustrations and designs have evidently been selected with care. The matter is printed on buff paper, though the examples for black and white drawing are printed on white paper. It is a faithful interpretation of the syllabus. C. H. S.

Three Crimson Days, by Harrison Patten. Pages 67, 13×19 cm. Neale Publishing Co., New York.

A magnificent little novel written by a former school man who evidently not only understands the internal workings of school politics but has as well a good knowledge of the ways of the world. It is written in a charming style and will not fail to command the attention of any reader. School folks especially will be interested in it as they understand the game better than the layman. For an hour's reading this is as fine a little story as ever was written. It should be read at a sitting. It abounds with humor, and the plot is cleverly conceived and worked out in an interesting manner. The type is large and clear, making the book one which is easily read. C. H. S.

Catalogue of High School and College Text-books, pages xxiv+519, 13×19 cm. Ginn and Company, Publishers, Boston.

This firm has surely discovered the way in order to make its catalogue of value to those who are interested in the books which they publish. It is of convenient size and well bound in cloth so that it may become part of one's library. It is a useful and usable catalogue for information concerning this firm's books. A list of their new and forthcoming publications is given, followed by a complete list of all of their books. The name of each text is given together with the author's name and institution with which he is or has been connected. The size, kind of binding, number of pages, and cost are also stated. In many cases a short description of the contents of the books listed is given, along with testimonials from people who have used them. The many books named are listed under proper heads so that with the aid of the complete index one is able to find quickly any book described. Teachers, superintendents, trustees, and users of high-school and college texts should possess a copy of this catalogue in order that they may make wise selections for their schools. The issuing of this splendid book shows the commendable business enterprise of the firm. C. H. S.

Elementary Practical Mechanics, by J. M. Jameson, Pratt Institute. XII+321 pages. 13x19 cm. Longmans, Green & Co., New York.

A splendid book which has incorporated in its pages work which is primarily intended for elementary technical and manual training schools. It can be used, too, in secondary schools where more than one year is given to physics. It is intended to give the user a fundamental practical knowledge of the more simple theories of mechanics and applications so that he will be able to apply these principles to advantage in everyday practical life.

It is not a book of spontaneous growth but is one where the subject matter has been thoroughly worked over in the author's classes for several years. Nothing is included which has not stood the test of actual class room work in elementary technical courses. The mathematics required do not extend beyond a knowledge of simultaneous and simple quadratic equations and to the simplest trigometrical functions.

One excellent feature of the book is the large number of carefully selected, practical problems which are well distributed. There are thirteen chapters in which matter is presented covering the entire field in an elementary text of this kind. There are 212 figures, most of which are entirely new. The half-tones are taken from apparatus in actual use. A complete index is given. Mechanically the book is well made and will stand hard usage. C. H. S.

Commercial Geography, by Edward Van Dyke Robinson, University of Minnesota. xxxii+455 pp. 15×20 cm. 1910, Rand McNally & Co., Chicago.

If a text-book is to have any value it must cause students to think. The desire to accomplish this end has been fully met in the text-book, "Commercial Geography," by E. V. Robinson. It has an interest not only to the student of Commercial Geography, but for anyone concerned with commerce, industry, and even history. Neither will there be an excuse longer for failure to teach Commercial Geography the right way.

In the older texts the subject matter comprised a mass of facts and information, with the entire emphasis on trade and transportation—useful enough to the geography reader, but wholly unrelated. In the preparation of this text, however, the author has adopted both the viewpoint that geographic conditions are the basic and underlying principles of commercial and industrial progress and development, but that the causal and interpretive phases are dominant, and that beside the influence of environment its scope must also include a "study of the localization of industry." Following this the author says that the "control of industries by physical environment is first." * * * after this a regional treatment properly follows. It is this logical treatment and arrangement that makes the geography absorbingly interesting and vital.

A dominant feature of the work is the maps, large enough to be distinct and easily studied and yet not so filled with detail that their purpose is obscured. In the collection of maps there are nine two-page maps of the continents, the highways of commerce, and areas producing the commercial staples of the United States. The numerous half-tones from photographs covering a wide range of interesting material from life in all parts of the world is an added feature.

Altogether the book is a mine of information and suggestion, simple and clear in style, and promises to afford an abundant source of interest to the student.

On the mechanical side the Geography is excellent, printed in large, clear type, and firmly bound in the new unbreakable binding. B. W. Broek.

The Training of Teachers for Secondary Schools in Germany and the United States, by John F. Brown. Pages x+335, 14×19 cm. $1.25 net. The Macmillan Company, New York.

An interesting and valuable book which should be in the library of every teacher who wishes to keep abreast of the very latest movements taking place in the preparation of secondary teachers. The material for this work was gathered at first hand by the author in 1909 while he was serving as exchange teacher of English in the *Oberrealschule* of the *Franckesche Stiflemgen* at Halle. He made a special study of German secondary education, laying special emphasis upon their methods of training teachers for this particular line of work. The book is divided into two parts. The first part of 200 pages gives a short historical account of the development of the methods of teacher training in Prussia during the last century, followed by a complete account of the methods as they are operated at present. In the light of Germany's experiences as a setting the author gives in the second part a synopsis of existing methods and practices in the institutions of the United States. In chapter XI he has outlined to considerable extent his ideas as to what should be done in this country in order to raise to a higher plane the training of teachers. The author's plans for the work combine the strongest elements in both the German and American methods. The book is written in a clear style, language well chosen, arrangement of material good, and for people interested in this line of work it is an excellent book to read and study. Coming from the press at the time when American educators are becoming more alive to the better training of teachers, it ought to have a large and wide circulation.

C. H. S.

The Story of Great Inventions, by Elmer Ellsworth Burns, Instructor in Physics at the Joseph Medill High School, Chicago, Ill. Pp. XIV+249. Price, $1.25. Harper & Brothers, New York, 1910.

In his well-known work on *Adolescence*, President G. Stanley Hall pointed out the need of supplementing the work in physics in high schools with the study of the history of science and the biography of great scientists. Teachers who have wished to follow President Hall's suggestion have, however, been much hampered in the past by the lack of suitable books which supply the needed material in a form suited to the pupils. "It was the realization of this need, growing out of years of experience in teaching these branches, that led the author to attempt the task of writing the story."

The author has succeeded admirably. It is a book that young people, particularly boys, will read with eagerness. It tells the things a boy wants to know in a simple and direct way without too much detail. Boys seek large wholes without too much detail, and this the book gives them.

The book is not a mere collection of stories from the history of physical science; they are arranged so as to portray in chronological order the lives and labors of those men who have made the great epochs in physics. Beginning with Archimedes, Galileo, Torricelli, von Guericke, Boyle, Pascal, and Newton are treated in turn. Then follow Watt, Franklin, Galvani, Rumford, Oersted, Faraday. The tales of these men and their work occupy the first four chapters. Chapter V is devoted to the great inventions of the nineteenth century—Electric batteries, the dynamo, the telegraph, the telephone, gas engines, steam engines, and turbines.

In the last chapter we read of air ships, aëroplane, submarines, the monorail car, liquid air, the electric furnace, wireless telegraph, the wireless telephone, the alternating current, X-rays, and radium.

An appendix contains brief notes on important inventions, giving the dates and names of the inventors of such useful things as reapers, barbed

wire, automobiles, bicycles, illuminating gas, blast furnaces, photography, and printing.

Great care has been taken to have the illustrations, of which there are 119, authentic photographs and careful drawings of the original apparatus used by the great discoverers.

Teachers of physics and parents of mechanically-minded boys owe a debt of gratitude to Mr. Burns for placing this valuable material at their disposal in so attractive a form. If any criticism can be made, it is that the treatment is too terse—the boys will want more of it. The book is heartily recommended to all as a valuable aid in humanizing science for the young.

C. R. M.

Municipal Chemistry, Edited by Charles Baskerville, College of the City of New York. 526 pages, 16×24 cm. McGraw-Hill Book Company, New York.

This book is a compilation of thirty lectures delivered by experts on different applications of chemistry at the College of the City of New York during the year 1910. The requests for the individual lectures in this course were so numerous that it was decided to incorporate the entire series into book form. One reading the book cannot help being impressed with the fact that those men who in general have charge of the administration of our municipal affairs should have a much better appreciation of the influence which a thoroughly competent municipal chemist can have upon the entire civic life of any city. Undoubtedly one of the most important offices in all of our larger cities should be that of city chemist. A person who should hold his position not by the whims of some political party, but by having passed a thorough and rigid civil service examination given by experts in the subject. The salary should be large enough so that competent men can be secured and held in the position for a series of years. A copy of this book should be in the possession of every city official so that he may realize more than ever the responsibility which rests upon him in having the city governed according to scientific business principles, thus returning to the citizens the greatest good for the expenditures made.

The book contains as many chapters as there were lectures delivered. The character of the work is best given by naming the headings of the chapters, namely: 1, "Sanitation and the City;" 2, "Drinking Water and Disease;" 3, "Municipal Water Supply, With Special Reference to New York's Catskill Mountain Waterworks;" 4, "Purification of Water;" 5, "Milk;" 6, "The Purpose, Method, and Extent of Food Adulteration;" 7, "The Remedy of Food Adulteration and Relation of Chemistry;" 8, "Food Inspection;" 9, "Drugs and Their Adulteration;" 10, "Methods of Detecting Adulterations;" 11, "Habit Forming Agents;" 12, "Streets and Their Construction;" 13, "Modern Road Construction;" 14, "Street Sanitation With Some Special References to New York City;" 15, "Methods of Street Cleaning and Waste Disposal of the City of New York;" 16, "Waste Disposal by Utilization;" 17, "Waste Disposal by Cremation, Incineration, and Destruction;" 18, "The Disposal of City Sewage;" 19, "Making Illuminating Gas;" 20, "The Valuation of Illumination Gas;" 21, "The Smoke Problem, With Some Special Applications to New York City;" 22, "Ventilation;" 23, "The Chemistry of Personal Hygiene;" 24, "Textile Materials and Their Service to Man;" 25, ""Combustibles and Explosives and Their Relation to the Fire Risk in Cities;" 26, "The Handling and Storage of Combustibles and Explosives;" 27, "Paint;" 28, "Corrosion of Iron and Steel;" 29, "Cement and Concrete;" 30, "Park, Gardens, and Playgrounds. The book contains 251 figures, illustrations, and charts. Mechanically it is well made, the type is clean ten point. It should have a large sale. C. H. S.

*An American Cyclopædia of Education and Some of Its Botanical Aspects.**

The profession of teaching is now the largest in point of numbers of all the professions. Its literature also is very great and extremely varied. In addition to the hundreds of volumes on educational subjects issued each year in this country alone, some hundred and fifty educational periodicals published in the United States assist in creating a national literature of education so extensive that the rank and file of the profession cannot hope to have any extensive acquaintance with it. When to this we add the British, French, and German works it is evident that not only the casual observer, but also the expert needs some guidance.

Heretofore there has been no attempt made in English to bring the essentials of this knowledge into a systematic and available form. It is to supply this very evident need that the Macmillan Company are bringing out, under the editorship of Paul Monroe, their new Cyclopædia of Education, the first volume of which is just off the press. The present writer would not presume to criticise in detail a work of such broad scope. It may be observed in passing, however, that the selection of topics treated appeals to one as extremely interesting and likely to contain precisely the information that one may be seeking. The first volume contains about a thousand titles. The hundred authors who have contributed are among the best known specialists in America; their names are a guarantee of the authenticity and general excellence of the articles.

The limits of the first volume (A to Chu.) are such as to include the principle titles in agriculture, astronomy, botany, and chemistry. Among the names which will be familiar to biological readers are Bailey, Caldwell, Coulter, E. Davenport, Gager, True, and Wilson.

The botanic gardens of the world and their educative meaning are treated by C. Stuart Gager. The history of each of the great gardens is traced briefly and a clear account is given of their educational work. Eleven gardens are thus treated in some detail.

The article on "Botany" is written by Professor J. M. Coulter and Dr. Otis W. Caldwell. Professor Coulter has contributed a summary of the history of botany as an academic subject in the wonderfully illuminating style which is characteristic of his writings.

He is a master of the mother tongue and is at his best in presenting the essentials of such a topic as this while subordinating the details without suppressing them. The view which is given of the past of the science is not that of a colorless and monotonous succession of incidents; rather it is a sequence of real events, grouped in such a way as to emphasize significant movements and epochs—a stereoscopic picture of the past. There is no other place known to the writer in which the background of the science, out of which present conditions have evolved, is so excellently presented. It is to be hoped that the same author will sometime find time to give us an account of the development of American botany, to which he has contributed so much during its most significant periods.

The distinctly pedagogical aspects of botany, both in America and abroad, are treated by Dr. Caldwell. The actual present position of botany in the schools, particularly in those of secondary grade, is summarized; the evolution of the teaching of the subject is traced, and the preparation of the teacher discussed at some length. It differs from most things that are written regarding the teaching of botany—or of other sciences—in that it is not a presentation of the author's views regarding the methods that ought

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*A Cyclopedia of Education, Paul Monroe, editor, Vol. I, A—Chu., Macmillan Company, 1911.

to be used; it is a statement of the conditions existing at present and in the past, in so far as it is possible to ascertain them. The article is likely to stand for some time to come as the standard statement of conditions and the point of departure for further investigation of the pedagogy of the subject.

Agriculture and agricultural education are treated at considerable length by several of the authors mentioned above. In the nature of things there can be little that is new in the articles, but the average teacher of botany will find much that is new to him both in the history of the movement and in regard to its present status. The present vigorous propaganda for the introduction of agriculture into the high schools at the expense of other subjects gives added importance to this statement of the history, methods, and present status of agricultural education.

A layman in chemistry should not presume to review the article on that subject by Dr. Smith. Merely by way of directing the attention of teachers to it, we may note that the author does not hesitate to attack the pedagogical problems involved. W. L. E.

Light and the Behavior of Organisms, by S. O. Mast, Ph.D., Associate Professor of Biology, Goucher College, Johnson Research Scholar, Johns Hopkins University (1907-1908). Small 8vo. XI+410 pp. 35 figures. John Wiley & Sons, Publishers.

While this book has the rather broad title of "Light and the Behavior of Organisms," it is as the author himself says, "A study of the perplexing and interesting question as to how organisms regulate their activities so as to bend or move toward or from the source of stimulation," yet the title is justified as it is really "a treatise on the behavior of organisms based on their reactions to light."

There are four main parts to the book. In the first part a general introductory chapter clears the field and analyzes the problem to be treated in this volume.

Nearly all organisms that are capable of changing their location or direction in space are influenced by light and this is the reason the subject has such a wide interest and bearing in the study of the behavior of organisms. The author's burden is increased because others have not been specific enough and consistent in their statements. Does he bear in mind that if all this had been done there would be less use for his book? He maintains that the work of many investigators on light reactions loses value because they do not distinguish between light on, or passing through, the organism, and light outside of the organism or in space around the organism ("in the field"). This holds for both ray direction and intensity. The position of the sensitive parts of the organism has not been sufficiently understood or reckoned with in the past. The author's well-known work on Volvox amply bears out this claim.

These are criticisms that most biologists will consider valid, but the matter of adaptation being a satisfactory explanation of behavior in response to light will continue to be debated.

In the historical review (Chap. II) the credulous notions of the Ancients about animal behavior are set forth, followed by the vitalistic and then the mechanical explanations. The acceptance of evolution gave a great impetus to the study of plant and animal behavior. This the author attributes to the concurrent belief that the mental faculties were likewise evolved.

The value of the concluding chapter in Part I is that it gives the historical setting not only of the tropism theories, so-called, but also brings out the bias of each of the investigators, some of whom have contributed to the present confused status of that much maligned theory. After reading

the citations of fifteen different ways in which the concept tropism is used by prominent investigators, it is evident that the author's criticism is mild when he says, "Nearly every reaction in living organism comes under one or another of the various definitions given to the term tropism."

The botanist Sachs seems to have been about the only one of the earlier and even of the later writers to make very exact statements in regard to *how* organisms orient in light. He maintained that the direction in which the rays passed *through* the organism, not through the medium surrounding it, nor the direction in which the rays strike the surface of the organism, is the cause of orientation. Even those investigators who believed they were extending Sachs' findings to animals and quoted him, did not make the proper distinctions.

While recognizing the services of Loeb and his school in counteracting the tendencies of those who would interpret responses anthropomorphically, the author champions the views of Jennings and his followers, who hold that the internal conditions (physiological states) must be taken into account in any explanation of behavior resulting from external stimulation.

In Part II follow the author's rather numerous investigations covering not only a wide range of animals but also special studies on plants, familiarity with which has stood him in good stead. Though the author's observations on orientation of plants in light do not bear out some of the theories so far held, yet he modestly disclaims settling the problem.

Animals react to light by change of motion or position, or by taking "a definite axial position with reference to the source of stimulation." The latter constitutes "orientation." Previous investigators have ascribed orientation in light to ray direction or difference of intensity, or even to change of intensity. The author points out that these terms have been so loosely used, barring some exceptions, that it is difficult to tell whether light in the field (space surrounding the organism) or light on or through the organism is meant. From the author's insistence on this distinction being made one might expect that he would always use the qualifying expressions except where the context makes it clear. Yet this is not the case as a few lines will show, e. g., page 230, lines 23, 24, 33; page 233, line 12.

From all his observations the author has concluded that *change* of intensity of light on the organism is the effective stimulus for orientation, and not change of intensity in the field, nor direction of rays in the field, nor direction of rays through the organism, nor difference of intensity on different sides of the organism. Constant intensity stimulates but does not orient.

Change of intensity on the organism may be brought about in a field uniformly lighted whenever the more sensitive portion of the organism swings out of the axis of orientation. Another rather important conclusion is that an organism will generally orient between two sources of light and not in line with the stronger or weaker, if there is a difference, as was heretofore held. This was a necessary corollary of the ray-direction theory. Only in animals with image-forming eyes is this the case, as here light acts as a constant, directing, stimulus.

Much of the success of the author's own work is apparently due to especially devised and more accurate apparatus, and his detail work. He has shown that the erroneous conclusions of others have been as much due to defective apparatus and methods as to questionable reasoning. Furthermore, his detail study of what the individual organism does, instead of judging aggregates, is much insisted on throughout the book.

In Part III many observations and comparisons of the work of others are made to show that the behavior of organisms is adaptive and useful.

He says page 243, "The fundamental principle involved in orientation is that it is the result . . . of the effect of illumination on life processes." Reversal in the sense of response is thought to be brought about by the effect of light on metabolic changes, and is also adaptive. The second chapter of this part (III) is devoted to reactions not orientations, or aggregations, on account of light stimulus. They are associated with food-getting and protection.

In Part IV we learn about response to colors—that "the shorter wave lengths are not the more active in all plants and animals, as has been held by others. 'Different regions of the spectrum are distinguished by honey bees, some fishes, birds and mammals, crustacæ, and probably some of the lower forms with well-developed eyes.' "

In the closing chapter on "Theoretic Considerations," there is a summary of the main contentions of the book. The behavior of organisms is "adaptive and regulatory;" even purposeful," as he quotes approvingly from Jennings.

In accordance with Jennings the author finds that reactions are due to change in "Physiological States," which may be due to chemical changes. This is in opposition to Loeb and others, who hold that the external stimuli directly affect (or by direct reflex) the motor mechanism. He goes a step farther than Jennings in analyzing the question, "What is it that regulates the physiological states?" While the neovitalists' views are entertained in the discussion, we are not disappointed in finding finally the same conservatism that has characterized the author's conclusions all through. Instead of making sweeping generalizations he is content with " . . . the distinguishing characteristics of living matter, have not as yet been accounted for mechanically."

Considered from several points of view a good new book is always welcome, in whatever line it may be written. With the growth of the literature in the biological field, owing to the great number of workers and the special attention given to very narrow lines, it is difficult to keep pace even for general information. The historical account, the present bearing and future outlook are of use even to a worker in a neighboring field. The specialist in the same line will derive less from a book of this kind unless the author is an authority, or has new material which is given only in his book, as is the present case. Especially for the promulgation of theories are such special volumes valuable as they are better rounded out and substantiated by all facts that an author can command.

The author has evidently made a very painstaking survey of the literature on the relations of light and organisms, and it will be a valuable source of reference for others. It is not evident why such work as Conant and Berger's monograph should not be included. The work of the publishers is done in their usual good style, though it is marred by careless final proof reading, the omission of letters in words occurring, e. g., page 236, line 19; page 238, line 9 from bottom. In the reviewer's copy pages 180 to 197 are also missing, being replaced by a duplicate of pages 165 to 181.

L. MURBACH.